Light Up Your Life!

Pan Canadian SCIENCE PLACE™

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Light Up Your Life!

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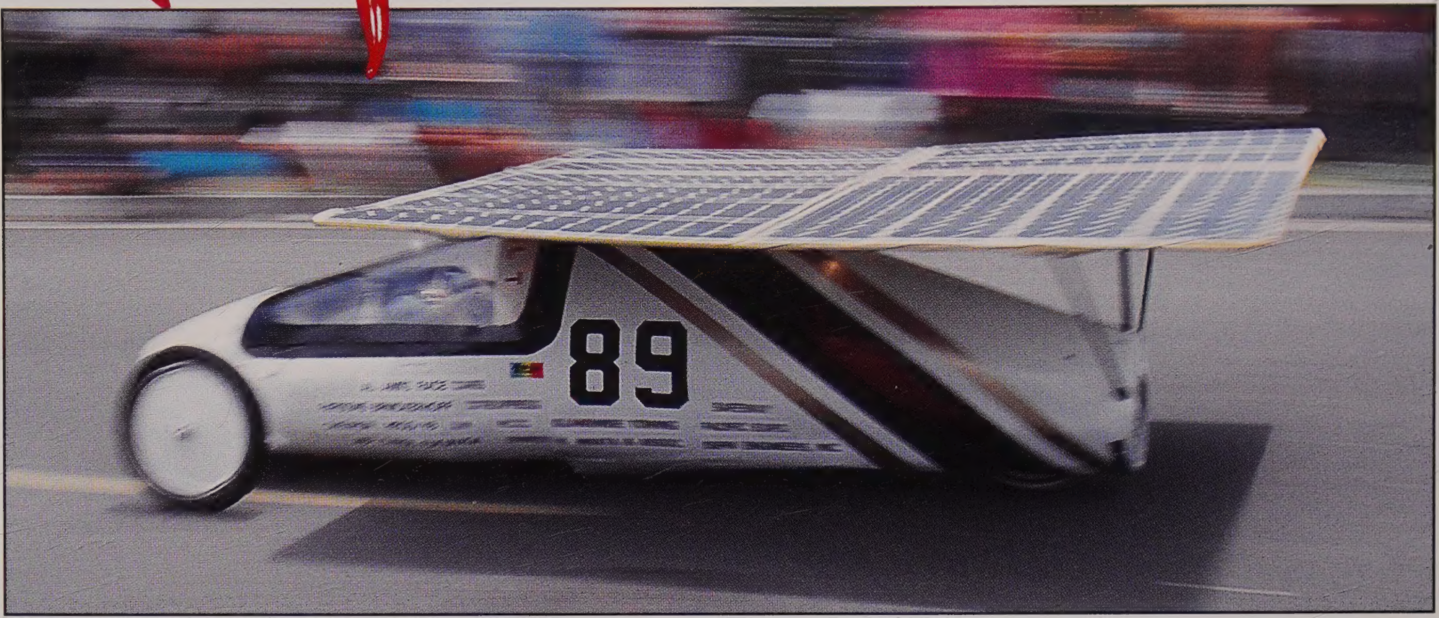

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Glossary 48

This symbol tells you when to write in your science journal.

Words in **bold** are explained in the glossary on page 48.

This symbol shows you Be Aware! when to be careful.

This symbol tells you when something you have learned may help you with the Think Tank.

Turn on the Light!

Have you ever thought about why you cannot see anything in a dark room, and why turning on the light makes it possible to see? What exactly happens inside your eyes once the lights go on? The questions could go on and on. Light is amazing. You cannot hold it in your hand. It doesn't have mass. All day long, the sky is bright with light that doesn't cost you a penny. But if you want light after dark, it will cost you.

What do you know about light . . . and what would you like to find out? In this unit, you will explore a truly wonderful form of energy—light!

What do you know about light?

Thinking about light is a little like thinking about breathing. Both are such basic parts of your life that you may never have thought much about them. Still, you already know some things about light. Work with your group to make a list of what you already know.

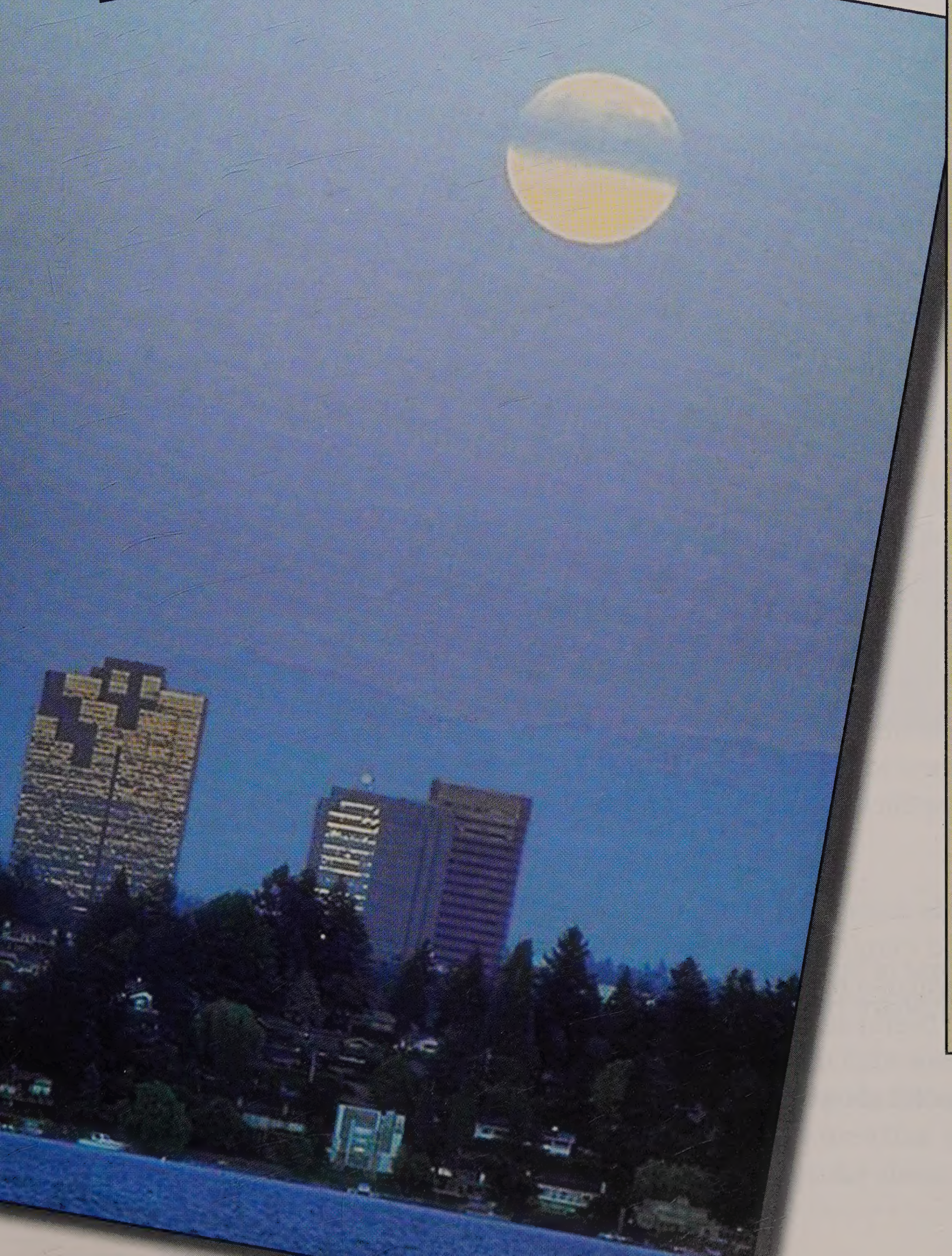
What do you want to know?

Make a second list. This time, list questions you have about light: Does the moon give out its own light, or does moonlight begin somewhere else? What causes jewels to glitter? And . . .

How will you find out?

You are going to work in group to do the hands-on explorations i this unit. You and your group members will discover many of th answers to your questions. You will also share information discovered by other groups in your class, and by other scientists.

Think Tank
At the end of this unit, you will use what you have learned about light to solve a problem—how to light a space station. In a group, you will talk about solutions and make a plan. Then you will design and present a model of your lighting system. The symbol tells you when something you have learned may help in solving your Think Tank problem.



Using scientific methods:

Scientific Inquiry

Science is about asking a lot of questions and trying to find answers. To discover what sorts of questions you will be exploring in this unit, read the table of contents on pages 2 and 3.

One way scientists use to find answers to questions is called the process of scientific inquiry. You, too, can use scientific inquiry to answer questions. Just follow the steps below.

- Ask questions about the problem to help you define it.
- Make a hypothesis—a statement about a possible answer or solution to the problem. Is there a way to test your hypothesis?
- Design an investigation to test your hypothesis.
- Collect the materials you will need.
- Conduct your investigation.
- Record the results of your investigation.
- Draw conclusions from your results. Was your hypothesis correct? Give reasons why or why not.
- Communicate your results and conclusions with others.
- If possible, relate what you have learned to the world outside the classroom.

LESSON 2

Where Does Light Come From?

Look out the window. What makes it possible for you to see the things outside? **Light** is the form of energy that lets you see. Where does this light come from? Most light comes from the sun—about 150 million km away! Because the sun **emits**—gives out—its own light, you do not need to shine light on it to see it. So the sun is a natural source of light. Other objects **reflect**—bounce—light from a source. What objects do you know that reflect light? Does the moon emit or reflect its own light? How do you know?

Exploration:

Identify light sources.

Besides the sun, what are some other sources of light energy in your everyday life?

❶ Look around your classroom. How many sources of light can you find? List each source and the ways you use the light it makes.

❷ Think about the ways you use light at home. List all the light sources at home and their uses.

❸ What are the sources and uses of light in the picture of the carnival? How else do you use light outdoors? Record these sources and uses.

❹ Now organize your lists into a table. Title the first column “Sources of Light.” Title the second column “How Light Is Used.”

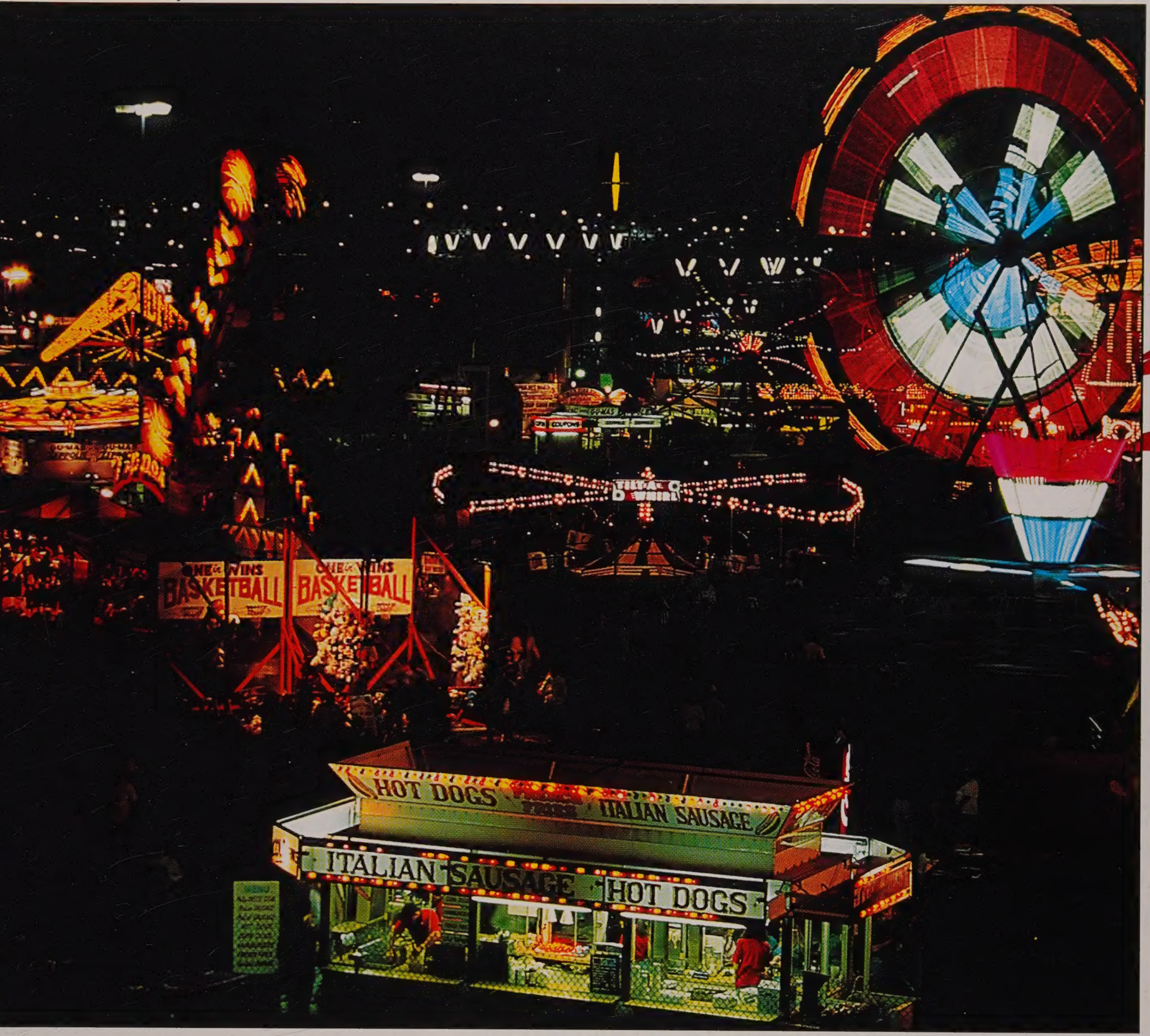
Interpret your results.

- Read the items in the first column of your table. Which items could be labelled natural sources of light? Which ones could be classified as artificial—that is, light made by humans?

Communicate your results.

- What is the most common use of light? How often do you use light for entertainment? Share your ideas with the class.
- Write a report or make a poster about light in your life.

▼ Light is a form of energy that people use in many ways. What sources and uses of light can you find in this picture?



Exploration Connection:
Lights in the sky

The sun is not the only source of light in the sky. In fact, the night sky is filled with billions of sources of light. Look at the table you just made. Did you list any natural sources of light that are usually seen at night? If not, add these to your table now. What are these natural sources of light and how is their light produced? Share your ideas in a group discussion.

To find out more about natural light at night, look in library books, CD-ROMs, and other print and non-print resources. You will probably be surprised to discover what some of those night light sources and uses are. Add them to your table, along with any other sources and uses that you think of while you are learning about light.

The sun gives off light energy because it is very hot. A nuclear reaction deep inside the centre of the sun produces great amounts of heat energy, and the heat energy makes the sun glow. But what makes a light bulb glow? What makes the bulb in a flashlight light up?

Exploration:
Light it up!

You need:

- flashlight with batteries
- magnifier
- 13 cm insulated copper wire
- scissors
- ruler

❶ Carefully take the flashlight apart to find out how it works. Locate its energy source. Observe its bulb with a magnifier. Make a sketch of the inside of the bulb.

❷ With your scissors, carefully cut off 6 mm of insulation from each end of the wire.

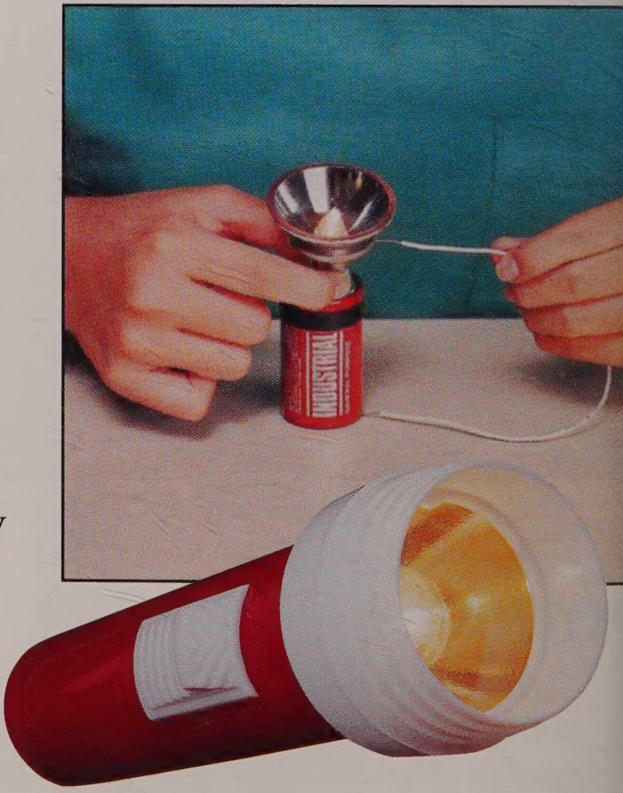
❸ Place the bulb on the battery so that the bottom of the bulb touches the tip of the battery. Touch one end of the wire to the bottom of the battery.

❹ Touch the other end of the wire to the metal side of the bulb. As soon as the bulb glows, you have completed an electric circuit.

❺ Just barely touch the glowing bulb. What form of energy do you feel? Look at the bulb. What energy do you see?

Interpret your results.

- Chemicals in the battery produce **electric energy**. How does electric energy get from the battery to the bulb?
- The tiny wires inside the bulb change the electric energy to another kind of energy that you can feel. This kind of energy changes to light energy. What is the kind of energy you can feel?



Communicate your results.

- Based on your observations of the sun, the flashlight, and the circuit you made, what do you need to produce light energy? Share your answer in an oral report.

HOW A STOVE AND CANDLE CHANGE ENERGY

▲ Electric energy flows through the cord into wires connected to the burner.

▲ The metal burner changes the electric energy to heat energy.

▲ The burner gets so hot that some of the heat energy changes to light.

▲ Candle wax can join with oxygen in the air to release energy.

▲ Adding a small amount of heat energy can light a candle wick.

▲ Heat energy makes the candle wax melt. When the wax gets hot enough, it burns and gives off heat and light energy.

Exploration Connection:
Forms of energy

Energy is like the ability to change something or to do work. The battery you used and the candle in the diagram have chemicals that can change to release energy. The energy in these objects can be used whenever you need it. What else can you think of that contains stored energy?

As you can see from the diagram, energy comes in many different forms. Energy can also change from one form to another.

Study the diagram. Both the candle and the stove change one form of energy to another.

Which device works more like a flashlight works?

Think!

What kinds of energy changes happen when a person lights a match?

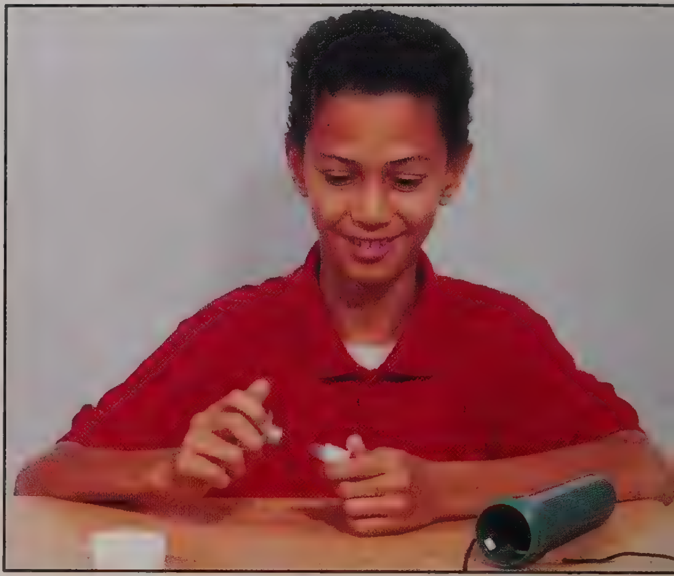
How Does Light Travel?

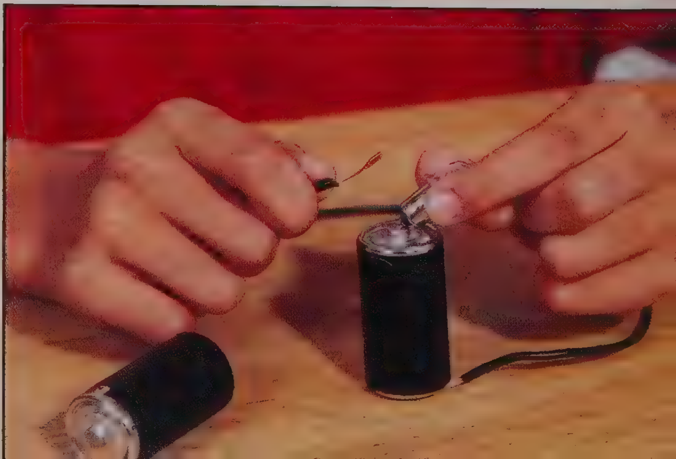
You have learned that a flashlight uses electric energy to produce light, and that a candle uses chemical energy to produce light. An electric stove changes heat energy to light. You know that light from a source takes time to reach your eyes. Light travels in a certain way. How do you think light travels from a source?

Exploration:

Observe the direction light travels.

You need:
- flashlight with batteries
- 13 cm insulated copper wire
- scissors
- ruler





❶ Take the flashlight apart and carefully remove the bulb from its reflector base.

❷ With your scissors, carefully cut off 6 mm of insulation from each end of the copper wire.

❸ Place the bulb on the battery so that the bottom of the bulb touches the tip of the battery. Touch one end of the wire to the other end of the battery.

❹ Touch the other end of the wire to the metal side of the bulb.

❺ Darken the classroom. Notice the directions the light travels out from the bulb.

❻ Open the curtains, or turn on the lights. Put the flashlight back together, and repeat step 5.

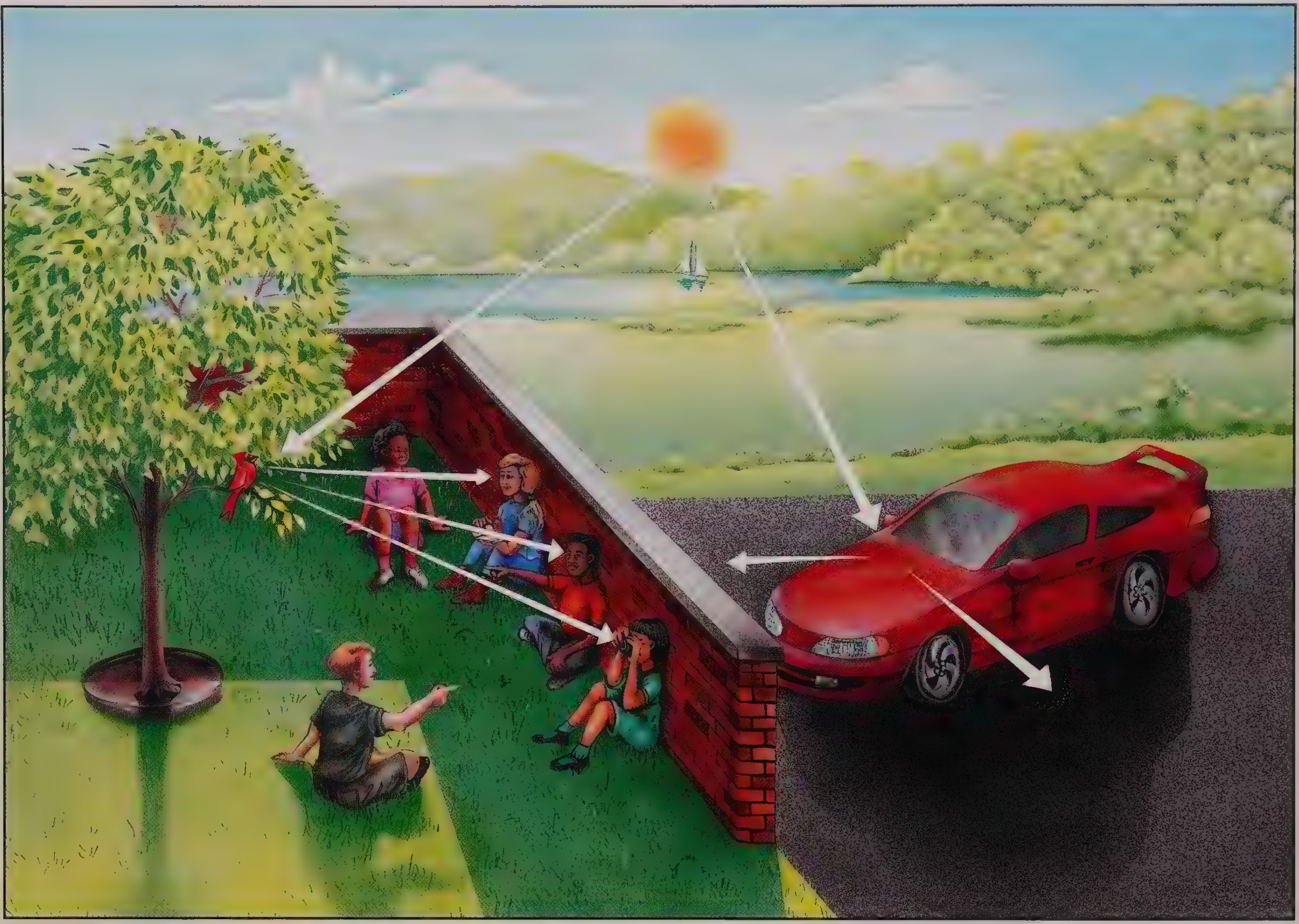
Interpret your results.

- When the bulb is removed from its reflector, in which direction(s) does the light come from the bulb?
- How does the pattern of light coming from the bulb without a reflector differ from the light from the assembled flashlight? Why?

Communicate your results.

- Discuss what you saw with a group of classmates.

HOW LIGHT IS REFLECTED TO YOUR EYES



Information Connection:

How you see things

Sometimes you see an object because it sends out light. Often, however, objects become visible to you when they are struck by light from a source. The light reflects off the object into your eye. What path does light take from its source to the object? What path do you think light takes from the object to your eye?

The diagram can help you answer that question. Use your finger to trace the light that comes from the sun and bounces off the tree into each person's eyes.

Most often you see objects because they reflect some of the light that strikes them into your eyes. Could the people in the diagram see the car? What does this tell you about the path light travels when it reflects off objects? Light travels straight and very fast. It gives you instant information about your world. You can learn something from even the tiniest amount of light.

You have learned one of the properties of light: No matter what its source, *light travels in all directions away from its source*. The light from a candle spreads out evenly. Light from a flashlight travels along a certain path. How would you describe this path?

Exploration:
Cast shadows.

You need:
- black construction paper
- flashlight
- stick
- ruler
- pencil
- tape
- books

The way shadows are cast can tell us a lot about the path of light from a source. Here is how you can use a flashlight, black paper, and a stick to investigate shadows:

❶ Cut a piece of black construction paper a little bigger than the front of a flashlight. Use a pencil to poke a tiny hole in the centre of the paper. Tape the paper over the front of the flashlight so that no light leaks from gaps between the paper and the flashlight.

❷ Work on a table or floor that is next to a wall. Stack a few books. Then place the flashlight on top of the books. Cut a square of black paper 5 cm on each side. Tape it to a short stick.

❸ Put the flashlight on a pile of books 30 cm away from the wall. Aim the light at the wall. Hold the stick with the black paper 3 cm away from the wall. Observe the shadow on the wall. Measure the size of the shadow.

❹ How will the size and shape of the shadow change if the flashlight is moved to a distance twice as far away from the wall? Put the flashlight on the books 60 cm away from the wall. **Try it!** Measure the shadow and record your results.

Interpret your results.

- You can make a diagram that shows how the shadow on the wall was formed. Draw lines to show the light's path from the flashlight to the paper square, and from the square to the wall.

Communicate your results.

- How accurate were your predictions about the effects on the shadow when the flashlight was moved twice as far from the wall? How does the distance of a light source from an object affect the size and shape of a shadow?

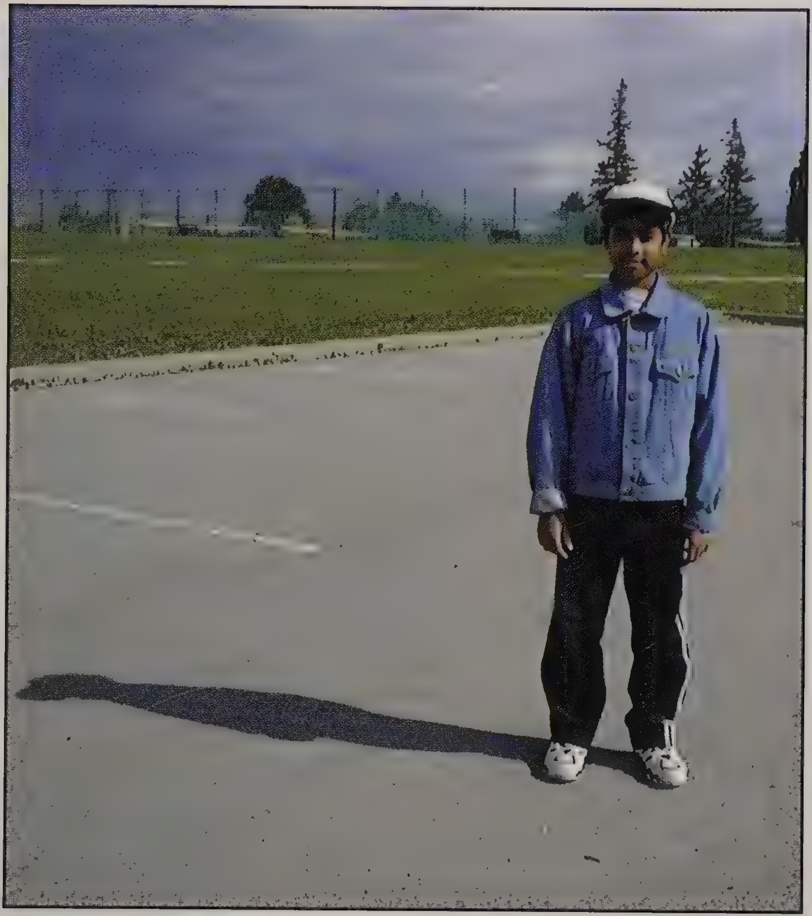
▲ This Indonesian shadow puppet is made of flat pieces of paper. It is placed behind a screen and a light source is set behind it.

Closer to Home:
Shadows throughout the day

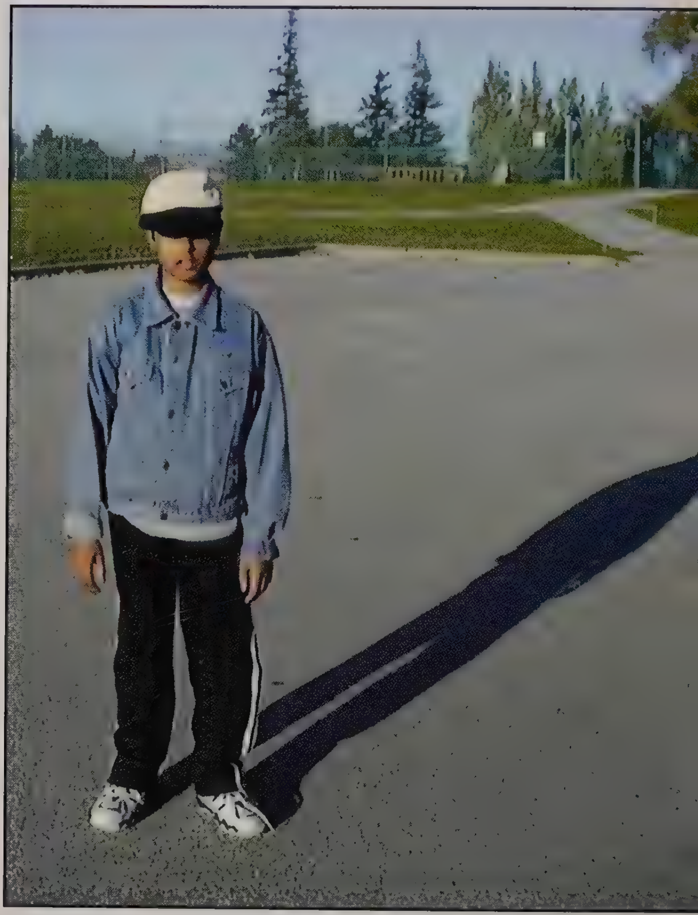
Have you ever noticed that, when you are outside, your shadow is shorter at lunchtime and longer at dinnertime? Why do you think this is so?

At noon, the sun is high in the sky. In the evening, it is much lower in the sky. Draw a diagram to show how the position of the sun changes the length of your shadow. How does time of year change your shadow?

Look at the picture of the movie projector on page 33. The light source in a projector is like a powerful flashlight. If you wanted the image on the screen to be bigger, would you move the screen closer to the projector or farther from the projector? If possible, use a projector to test your ideas.



▲ 12 noon on October 1st



▲ 6 p.m. on October 1st

Think!

There are many stars in our galaxy that are much bigger than our sun. Why does the sun appear to be much brighter than any other star?

LESSON 4

What Path Does Light Take?

As sunlight travels through space, its speed stays the same. This is another property of light: *Light always travels at 300 000 km/s if it is travelling through nothing* (in a vacuum). Light from a source travels along a certain path. What path do you think light takes?

Exploration:
Can light curve?

You can see a book on your desk because light from a source strikes the book and reflects into your eyes. Can you still see the book if the light has to curve to reach your eyes?

❶ Find a simple, safe object you can look through such as a straw. Work in your group to design an investigation using this object. Your problem is to find out if light can travel in a curved path.

❷ Make a hypothesis. Will you be able to see the book when the object you look through is straight? Will you still be able to see the book when the object is curved?

❸ Discuss your hypothesis. Record your hypothesis.

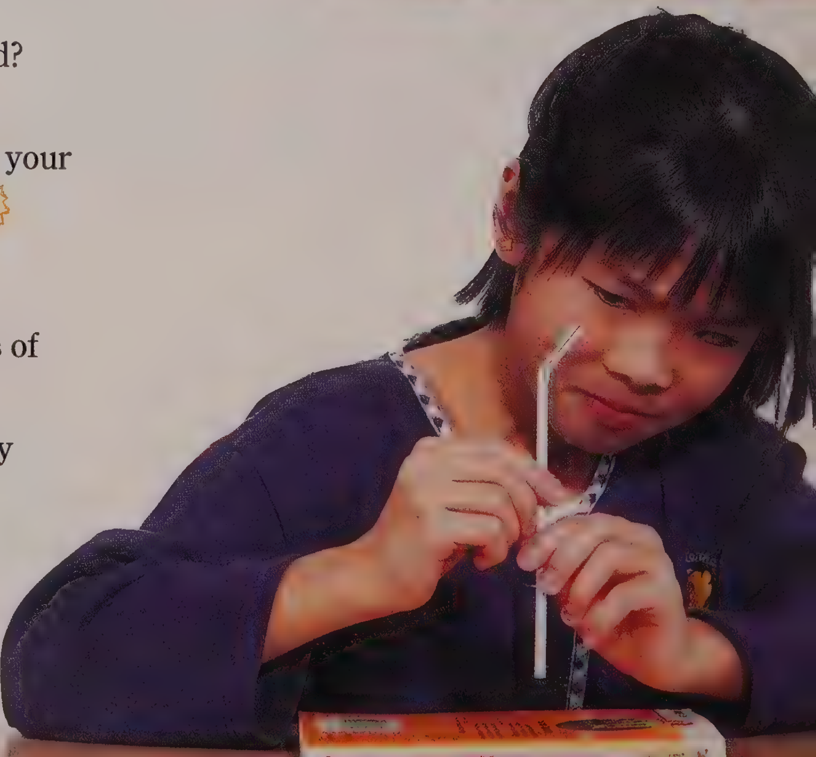
❹ What will testing your hypothesis tell you about the path of light? Record your ideas.

Interpret your results.

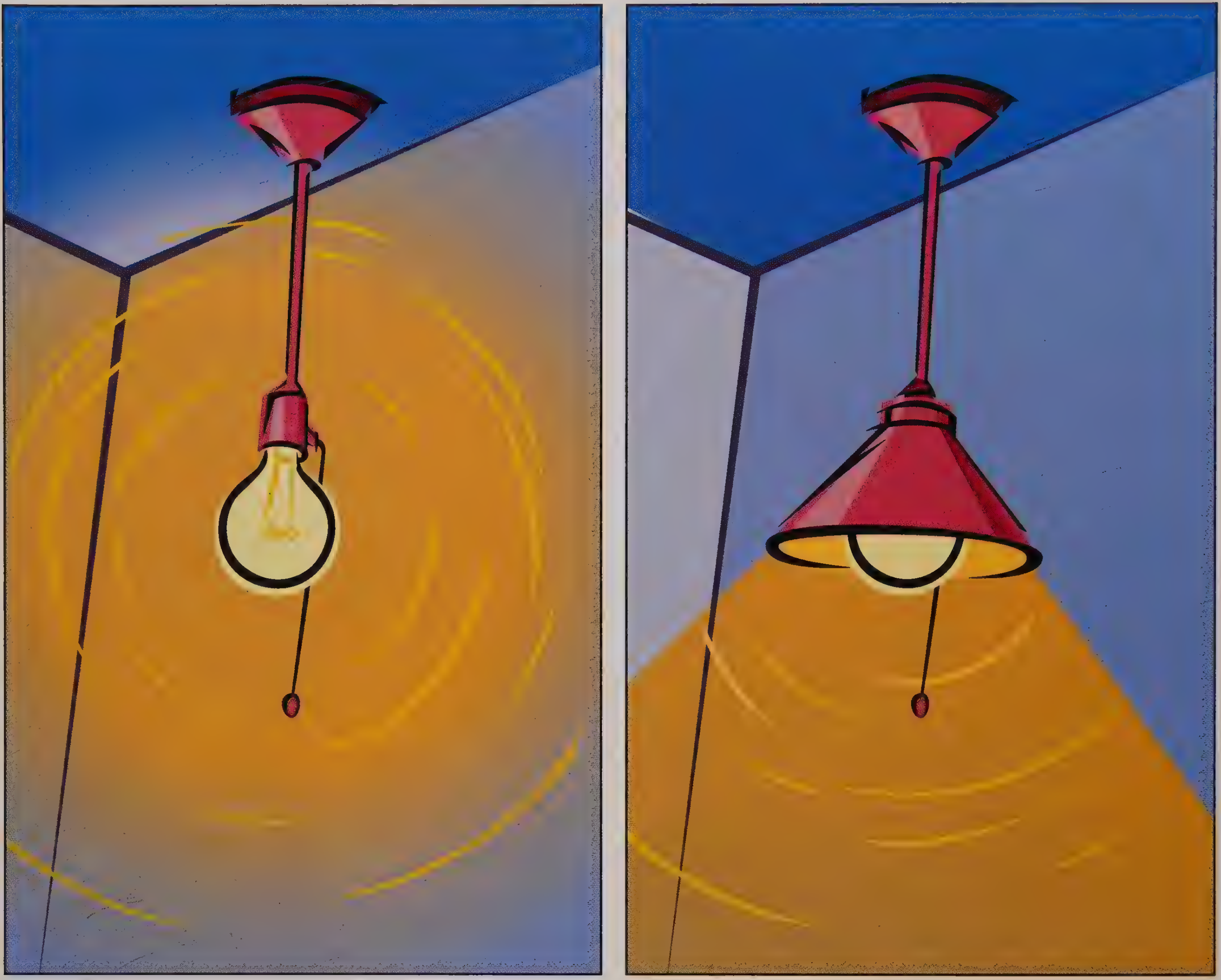
- When the object you are looking through is straight, can you see the book? Why, or why not?
- Can you see the book when the object is curved? Why or why not?
- Was your hypothesis correct? What has testing your hypothesis told you about the path of light?

Communicate your results.

- Compare the methods you used and the results of your investigation with those of other groups.
- Present your investigation to the class. Be ready to answer any questions.



HOW A SHADE CHANGES THE DIRECTION LIGHT TRAVELS



Closer to Home:
Lighting up your life

You have observed another property of light: *When light travels directly from a source to an object, it takes the shortest path—a straight line.* That is why you cannot see a book through a bent straw. Light does not curve. You have seen that light travels in straight lines in all directions away from its source. That's why a bare bulb will light up a whole room evenly.

But what about a flashlight? Why does the light travel in a beam and not in all directions from the bulb? In fact, the light does travel in all directions from the bulb, but the reflector just behind the bulb blocks the light moving toward it.

Light travels straight and fast. And nothing gives you as much instant information about your world. You can learn something from even the tiniest amount of light.

Exploration:
Make a pinhole camera.

You need:
- 2 cardboard tubes
- 2 pieces of black paper
- aluminum foil
- pin
- tracing paper
- tape

❶ Roll up the sheets of black paper and slide one roll into each cardboard tube.

❷ Cover one end of one of the tubes with a piece of foil. Hold it in place with tape. Push the pin into the centre of the foil to make a tiny hole.

❸ Cover the other end of the tube with tracing paper, and hold it in place with tape.

❹ Hold the second tube to the tracing-paper end of the first tube. Tape the tubes together. Make sure the tubes are tight.

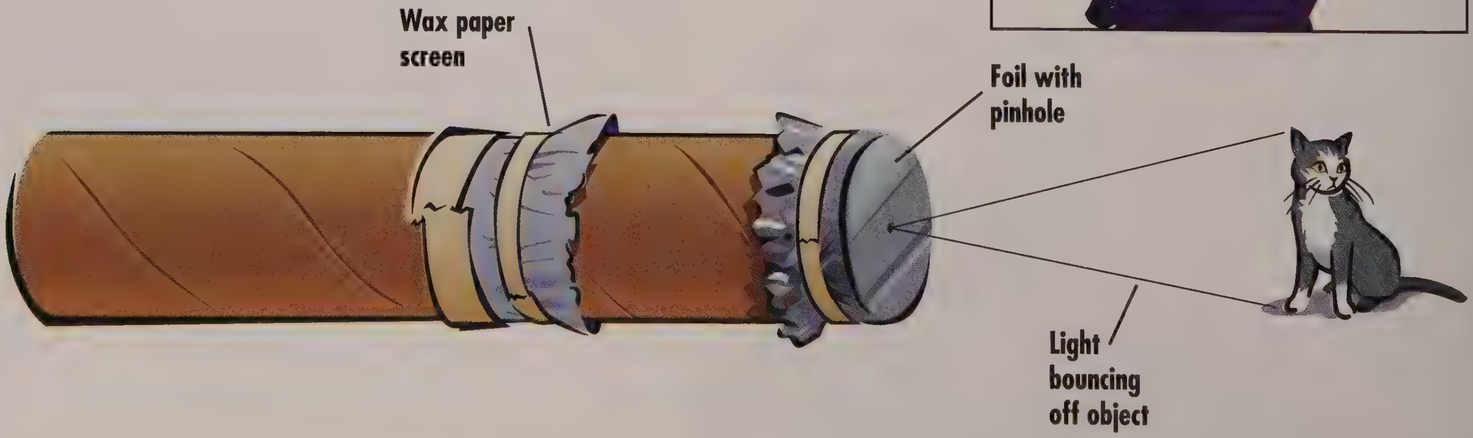
❺ Take your pinhole camera to the window. Before you look through it, find an object in bright light. Now aim the foil end of your camera at the object, and look at it through the open end of the camera. Be sure to cover the opening around your eye.

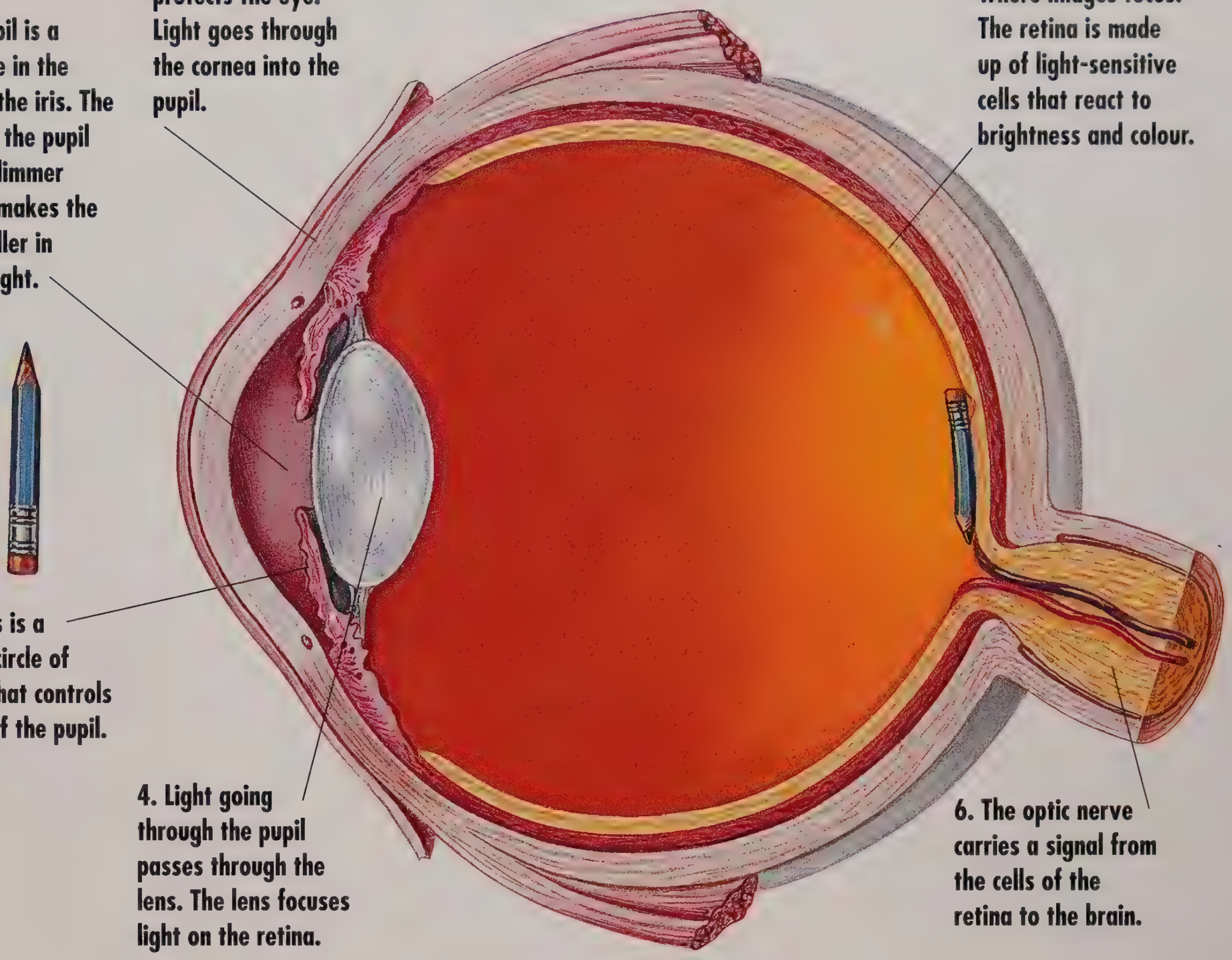
Interpret your results.

- How was the image in your pinhole camera different from the way the object looked without the camera?

Communicate your results.

- Draw a diagram like the one below. Finish it to show the path that light travelled to form the image in your camera.





1. The cornea is a clear cover that protects the eye. Light goes through the cornea into the pupil.

2. The pupil is a round hole in the centre of the iris. The iris opens the pupil wider in dimmer light and makes the pupil smaller in brighter light.

3. The iris is a coloured circle of muscles that controls the size of the pupil.

4. Light going through the pupil passes through the lens. The lens focuses light on the retina.

5. The retina is like a movie screen where images focus. The retina is made up of light-sensitive cells that react to brightness and colour.

6. The optic nerve carries a signal from the cells of the retina to the brain.

YOUR EYE—THE INSIDE STORY

Closer to Home:
The world's best cameras

Your pinhole camera is actually a model of how light enters your eye. Light reflected from an object travels right into your eyes, just as the light passed through the pinhole in the foil. But what happens to light inside the eye?

Use a finger to trace the path of light from the pencil through each part of the eye. Notice that the image of the pencil is upside down on the retina. The brain uses the nerve signals from the eye to make a right-side-up image of the pencil. If your brain did not do this, the world would look upside down!

- How is the pupil like the pinhole in your pinhole camera?
- How is the retina like the tracing paper that you used in your pinhole camera?

Think!

Even with very bright headlights, people have to drive slowly on curvy roads at night. Why?

LESSON 5

What Happens When Light Hits Smooth and Uneven Surfaces?

What happens to the path of light when it meets a smooth, shiny surface? And what do you think happens to light when it hits an uneven surface such as a tree or rock?

Exploration:

Shine light on different surfaces.

With a partner, talk about surfaces that can be both smooth and uneven. Where have you seen a flat, shiny surface that can be made uneven?

❶ Find a common, safe material with a smooth, shiny surface that can be crumpled to make it uneven. Work with your partner to design an investigation using this surface and a small light source you can move around safely. Your problem is to find out what happens when light hits

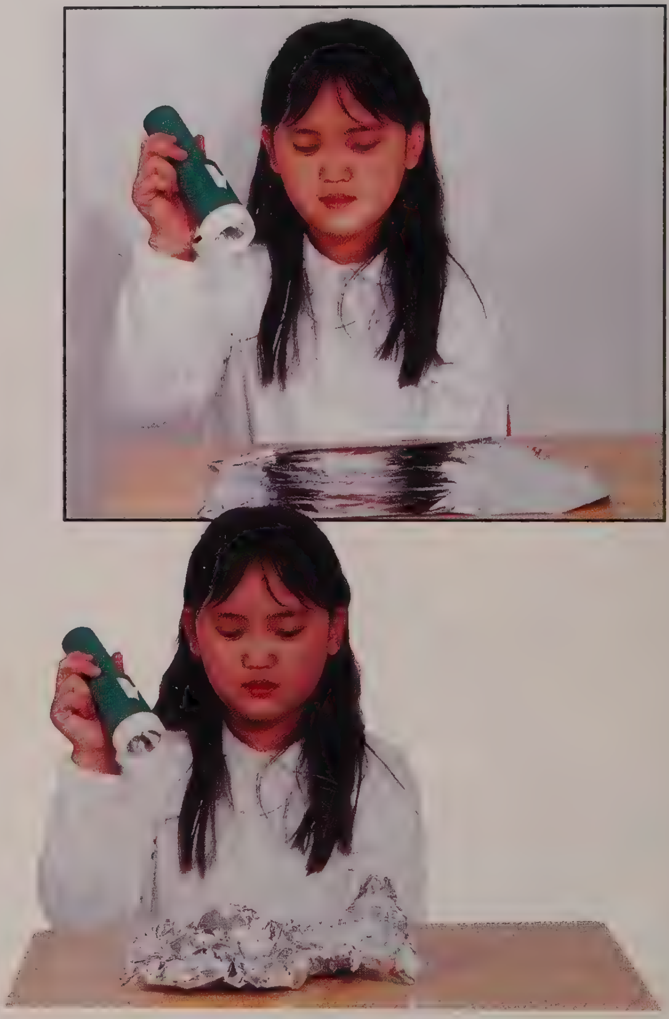
a) a smooth, shiny surface
b) an uneven surface

❷ What do you think will happen to a beam of light when it hits each of the two surfaces? Discuss your hypothesis. Then record your hypothesis in your science journal.

❸ What will testing your hypothesis tell you about the path of light when it hits different surfaces? Record your ideas.

Interpret your results.

- How did the smooth, shiny surface reflect the light beam? Could you see a pattern reflected on a wall by the light after it hit the smooth surface?
- How did the uneven surface reflect the light? Why?
- Was your hypothesis correct? What has your investigation told you about the path of light?



Communicate your results.

- Draw a diagram to show the light's path from the source to the flat surface, and its reflection. Draw another diagram to show the light path to the uneven surface, and its reflection. Share your diagram with the class. Be ready to answer questions.

HOW LIGHT IS REFLECTED FROM UNEVEN SURFACES

Closer to Home:
Scattered light

Why can people in different positions see the same object? Besides crumpled foil, lots of surfaces are uneven—a tree, a rock, a wall, or any other surface that is not smooth. You have observed another property of light: *When light strikes an uneven sufrace, it is reflected in many different directions.* That is why people in different positions can see the same object.

Imagine a group of people looking at the same rock on the beach. You could draw a diagram showing the path of light from the sun to the rock, and bouncing off the rock to each person's eyes.

Try it! You can use a computer to draw the diagram.

Think!

A movie screen appears to be a smooth, flat surface. Why do people in different seats in the theatre see the same image on the screen?

What Happens When Light Hits a Mirror?

You have observed this property of light: *Light is reflected from smooth, shiny surfaces in a very orderly way.* What do you think happens to light when it hits a very smooth, shiny surface—a flat mirror?

▶ A mirror starts out as ordinary glass.

Exploration:

Investigate images in a flat mirror.

You need:

- string
- scissors
- tape
- pen
- flat mirror
- folded paper
- ruler (measuring tape)

❶ Cut a 200-cm length of string and mark it every 50 cm with tape. Tape the string to the floor.

❷ Stand with your toes at the end of the string and face the wall. Have others tape the mirror to the wall so that you can see the tips of your shoes in the mirror.

❸ Ask group members to stand at each mark, hold the folded paper at floor level, and then slowly raise the paper until you cannot see your shoes in the mirror. The students should use string and a ruler to measure the height of the paper. Record the height of the top of the paper at each mark.

❹ Then the group members should stand again at each mark, hold the paper up in the air, and slowly lower it until you cannot see your shoes in the mirror. Record the height of the bottom of the paper at each mark.

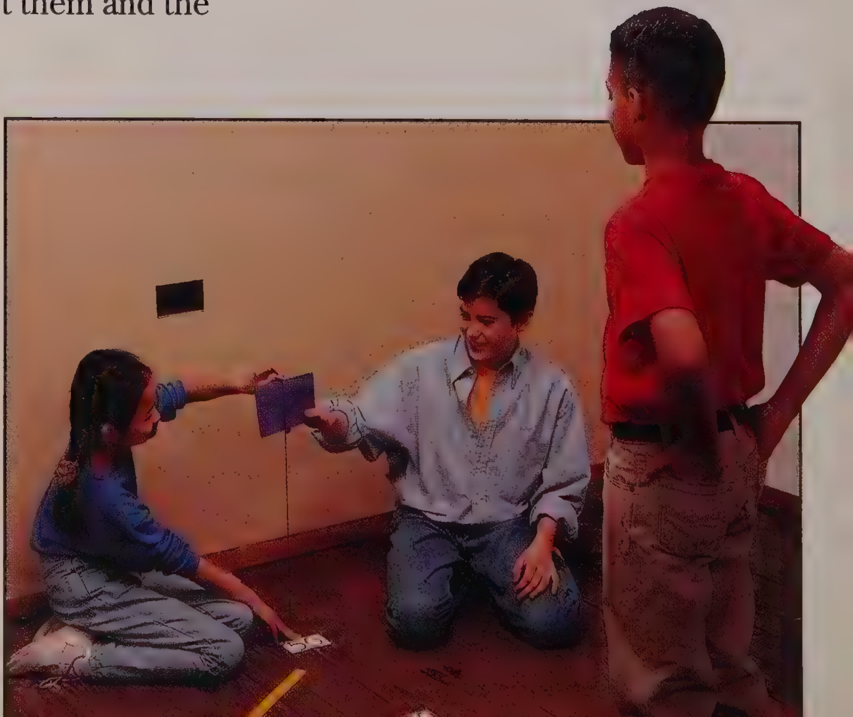
❺ Draw a graph. After finding the heights, plot them and the height of the mirror on your graph.

Interpret your results.

- How does the angle at which light hits a flat, shiny surface compare with the angle at which the surface reflects the light back?

Communicate your results.

- Write a short report to tell how the image in a mirror is different from the image you saw in your pinhole camera.

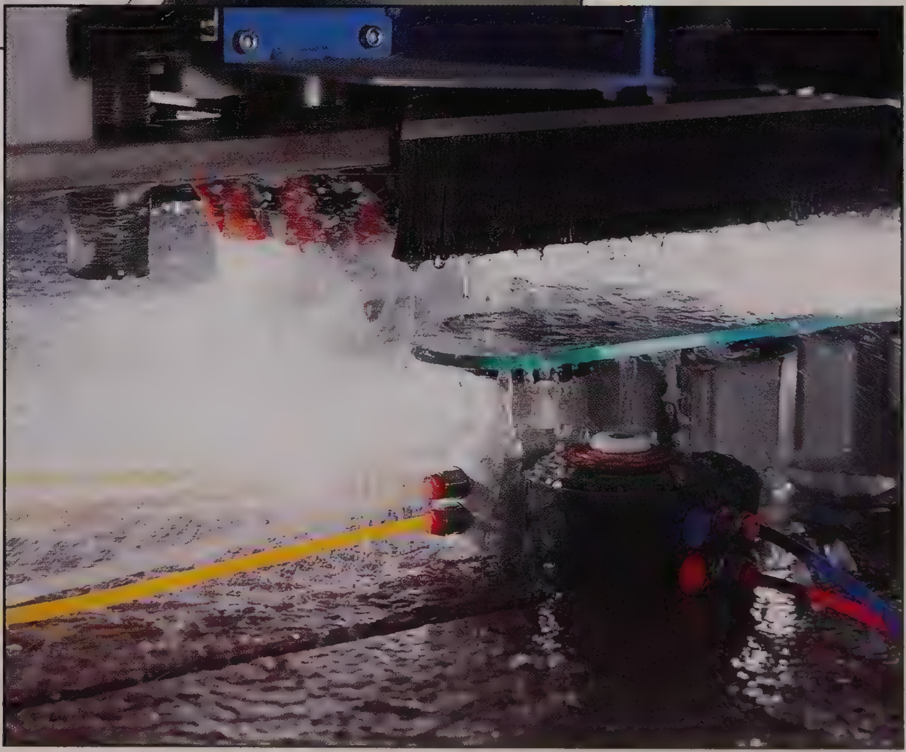


Exploration Connection:
Mirror, mirror…

The way a mirror reflects light can lead to many uses. Discuss and then make a list of some of these uses.

You and a partner have one flat mirror. How could you position yourselves and the mirror so that you would see each other in the mirror? **Try it!** Draw a diagram that shows how the path of light lets you see each other in the mirror. You can use a computer to make your diagram.

◀ A mixture of silver and other metals is sprayed onto one side of the glass and then hardened in an oven. What do you think the silver mixture does to the glass?



▶ After the mirror is cut to size, its edges are ground smooth for safety.

You have just observed this property of light: *Light is reflected from a mirror at the same angle that the light hits the mirror.* Mirrors can be tricky. The image in a mirror seems to be reversed. If you part your hair on the right side, your reflection in the bathroom mirror shows the part on the mirror image's left side. **Try it!** If a flat mirror does that to an image, what would a curved mirror do?

Exploration:

Investigate curved mirrors.

You need:
- white paper
- scissors
- ruler
- shiny metal spoon
- pencil or pen

❶ Cut a strip of paper 12 cm long by 3 cm wide. Draw two lines 1 cm apart from one end of the strip to the other. Draw 11 lines across the strip, 1 cm apart. Cut one end of the paper into a point.

❷ Hold the back of the spoon about 20 cm in front of your face. In your other hand, hold the strip of paper with the point in front of, and almost touching, the spoon. The lines on the paper should be facing the spoon.

❸ Slowly bring the strip toward your face without moving the spoon. See what happens to the reflection of the paper and the spaces between the lines.

❹ Repeat steps 2 and 3 with the front of the spoon toward you.

Interpret your results.

- When you moved the paper strip, how did the reflection of the lines on the back of the spoon change? on the front of the spoon?

Communicate your results.

- How is the image formed in a curved mirror different from the image formed in a flat mirror? Share your conclusions in an oral report.

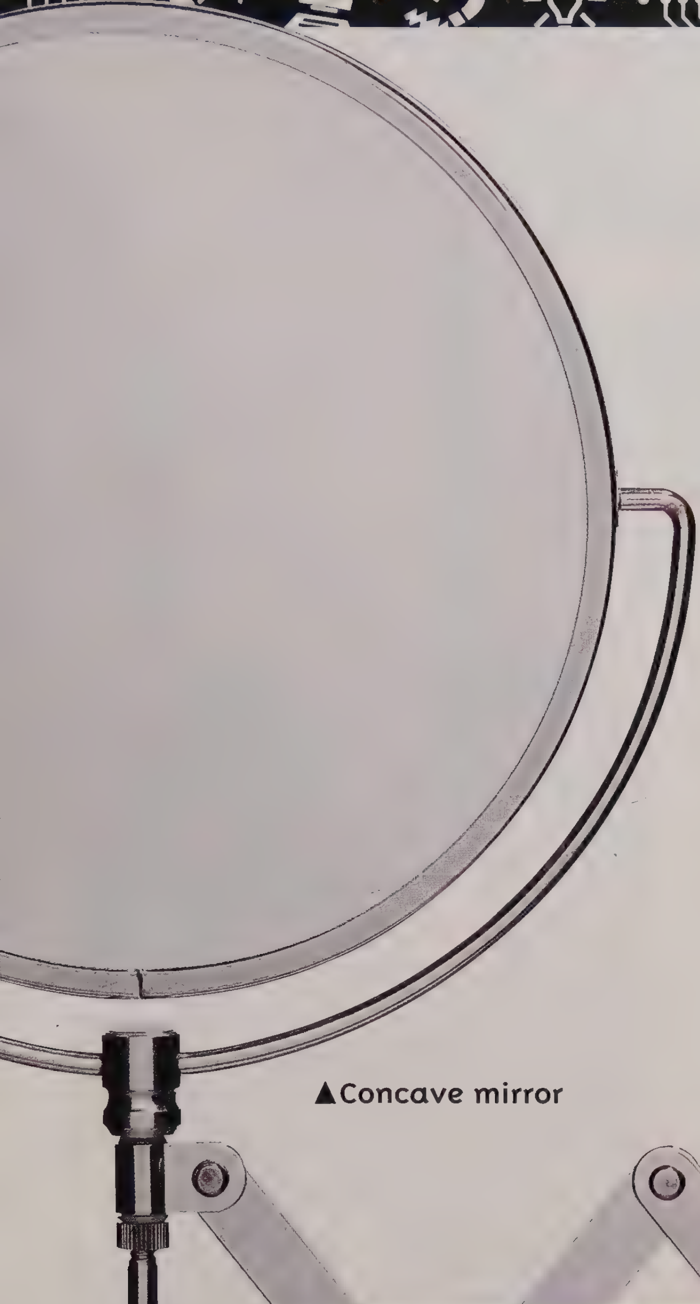
Closer to Home:
Mirrors for safety

Mirrors are often used as safety devices. A bicycle reflector is like many small, flat mirrors put together at different angles. All those flat, shiny surfaces reflect the light brightly in many different directions.

Curved mirrors are also useful as safety devices. A **convex** mirror, curved outward like the back of the spoon you used in the Exploration, is the kind of mirror used in cars to help drivers see what is following them. Because of the way a convex mirror reflects light, a driver can even see what is beside the car.

A **concave** mirror, curved inward like the front of a spoon, reflects only a small part of what is in front of the mirror. Many men shave in front of a concave mirror to avoid cutting their faces. The concave mirror reflects one small part of a face and makes it look bigger.

- Why does a convex mirror make an image that seems to be farther behind you than the object really is?
- How are flat, concave, and convex mirrors alike?



▲Concave mirror

▲ Most cars have a convex side-view mirror. These mirrors reflect light from a very wide area, but the image in the mirror is reduced. Why do you think this type of mirror is also used in some stores?

Think!

Many ambulances have the word AMBULANCE written back to front on them. Why is this so?

LESSON 7

Can the Path of Light be Bent?

Light can be reflected. But can the path of light be bent? Have you ever tried to pick up a coin on the bottom of a swimming pool? If you have, you know that it is not as easy as it sounds. You hold your breath, dive in, and reach for the coin—but when you get to the bottom of the pool, the coin is not where you thought it would be. What do you think is happening?

Exploration:

Can you bend a ray of light?

You need:

- coin
- paper cup
- spoon
- water
- clear plastic cup

❶ Put the coin on the bottom of the paper cup. Have a partner sit so that the coin is just out of his or her sight.

❷ Slowly add water to the cup one spoonful at a time. Ask your partner to observe the bottom of the cup but not to tell you what happens.

❸ Change places with your partner. Empty the cup and repeat steps 1 and 2.

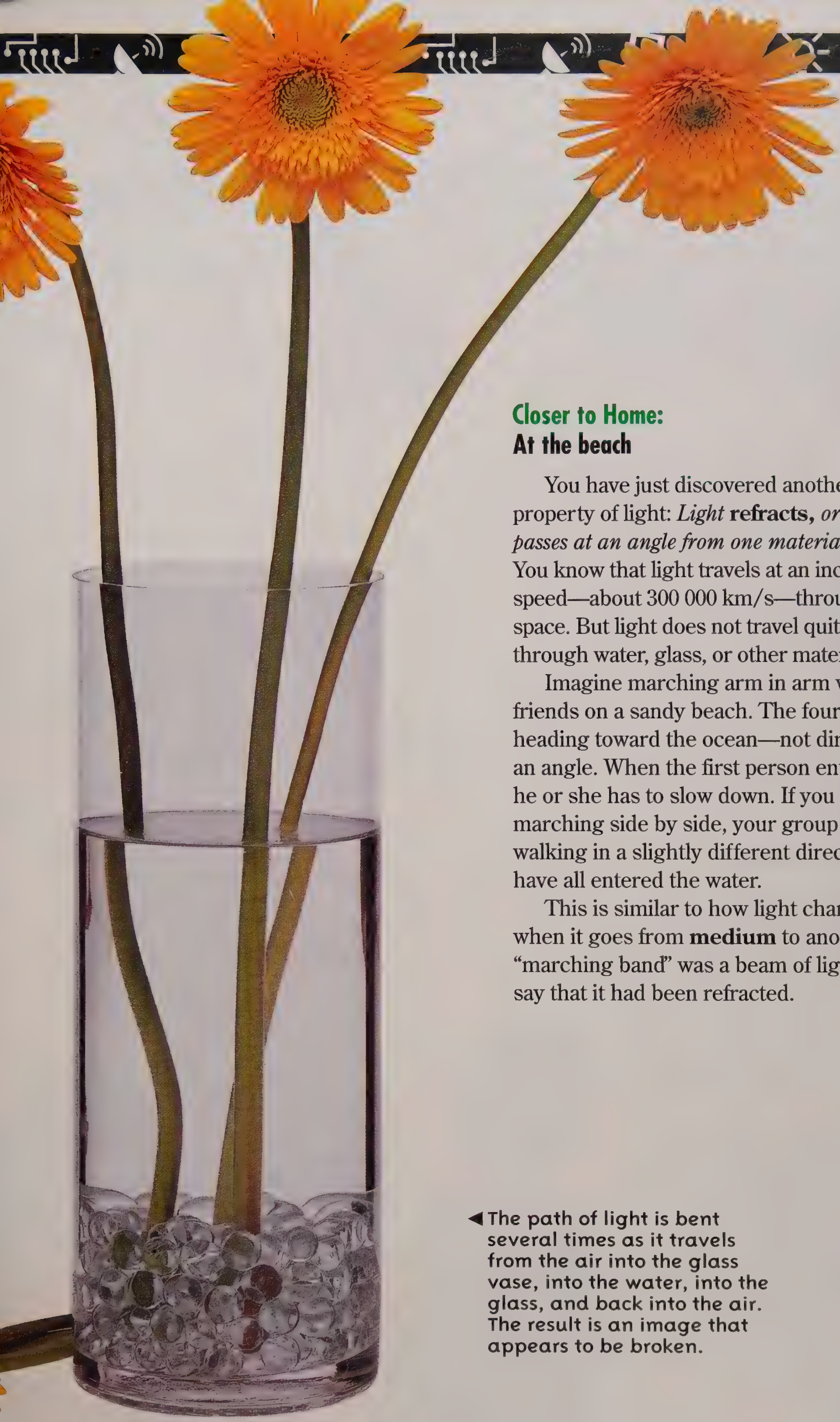
❹ Put the water and the coin into a clear plastic cup. Add more water to the cup until it is half full. Look at the top of the water from the side of the cup. How many coins seem to be in the cup? Record your findings.

Interpret your results.

- Could you see the coin on the bottom of the paper cup in step 1? Why or why not?
- What happened when water was added to the paper cup? Why do you think this happened?

Communicate your results.

- Write an illustrated report of your observations and conclusions to share with a group of classmates.



Closer to Home:
At the beach

You have just discovered another important property of light: *Light* **refracts,** *or bends, when it passes at an angle from one material to another.* You know that light travels at an incredible speed—about 300 000 km/s—through empty space. But light does not travel quite so quickly through water, glass, or other materials.

Imagine marching arm in arm with three friends on a sandy beach. The four of you are heading toward the ocean—not directly, but at an angle. When the first person enters the water, he or she has to slow down. If you want to keep marching side by side, your group will end up walking in a slightly different direction once you have all entered the water.

This is similar to how light changes direction when it goes from **medium** to another. If your "marching band" was a beam of light, you could say that it had been refracted.

◀ The path of light is bent several times as it travels from the air into the glass vase, into the water, into the glass, and back into the air. The result is an image that appears to be broken.

LESSON 7

Lenses—like the lenses in eyeglasses—refract light in a certain way. Refracting telescopes, magnifiers, and microscopes all have lenses that help you see things that are too small or far away to see with just your eyes. Like concave and convex mirrors, concave and convex lenses refract light in different ways.

▲ These steel-framed eyeglasses were made in the 18th century and were very expensive. Few people could afford to wear glasses at that time.

▲ Eyeglasses became much less expensive during the 19th century. How are these 19th-century glasses different from the 18th-century glasses? from glasses today?

Exploration:
Compare lenses.

You need:

- convex lens
- concave lens
- flashlight
- ruler
- coin

❶ Examine the convex and concave lenses. Feel the middle and edges of both kinds of lenses. How are the lenses different and alike?

❷ Hold the flashlight as in the picture. Use the convex lens to focus the light onto the tabletop. Focusing the light means moving the lens closer to or farther away from a surface until the light is aimed at one spot. This place is called the focus of the lens. Focus the light by raising the lens up or down.

❸ Have a partner measure the distance between the lens and the focus. This distance is called the focal length of the lens. Record this distance.

❹ Now place a coin on your desk, and stand about 60 cm away from it. Close one eye. Place the convex lens directly over the coin and slowly move it towards your eye. Record your observations.

❺ Try to repeat steps 2–4 using the concave lens.

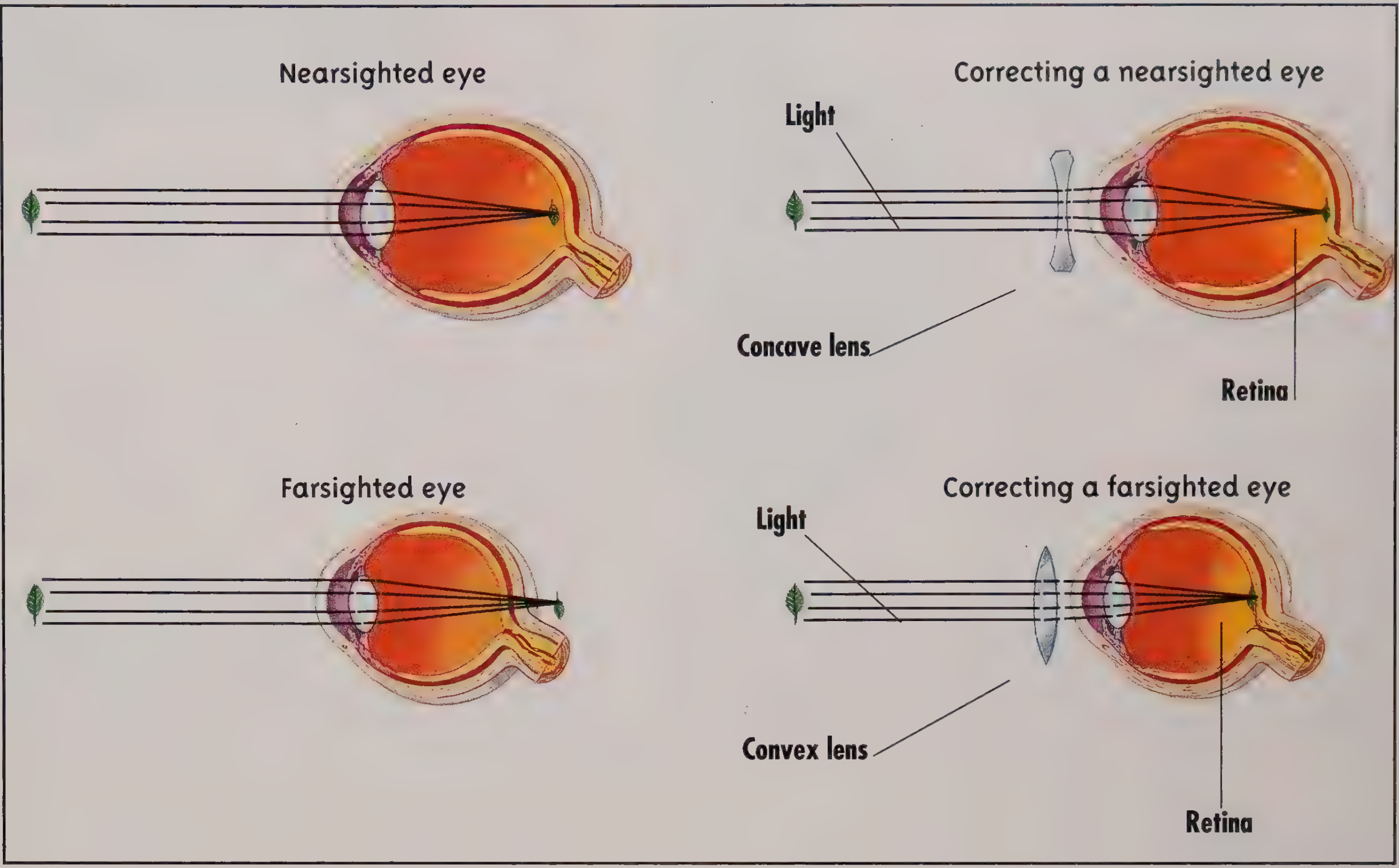
Interpret your results.

- How did the image of the coin change as you moved the convex lens?

Communicate your results.

- Draw a picture to show how the image in the concave lens was different from the image in the convex lens.

HOW LENSES CORRECT VISION



Closer to Home:
Seeing clearly

Think of your **retina** as a movie screen. For you to see clearly, the convex lens in your eye must focus light directly onto this screen.

In a farsighted person's eye, the distance between the lens and retina is too short. The lens focuses light from nearby objects behind the retina. A farsighted person sees distant objects clearly, but nearby objects seem fuzzy. Study the diagram. How does wearing glasses with convex lenses help farsighted people?

In a nearsighted person's eye, the distance between the lens and retina is too long. The lens focuses light from distant objects in front of the retina. A nearsighted person sees nearby objects clearly, but distant objects seem fuzzy. How does wearing glasses with concave lenses help nearsighted people?

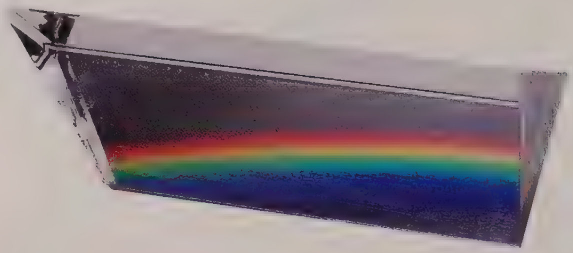
- Imagine that you have trouble seeing the print on this page. Which kind of lens could help you see the print clearly?
- Imagine that you have trouble seeing people's faces on the other side of the classroom. Which kind of lens could help you see across the room clearly?

Think!

When you are standing up to your waist in water, your legs appear to be shorter. Explain why.

What Is in White Light?

Mirrors reflect light. Lenses refract it. Some materials—or combination of materials—can do both. What do you think happens to a beam of light that is both reflected and refracted?



▲ This prism is a five-sided glass block. Three sides are long rectangles. The two smaller sides are triangles.

Exploration:

Separate white light.

You need:

- pan
- ruler
- water
- modelling clay
- mirror
- flashlight
- tape
- paper
- crayons

❶ Place the pan on your desk or the floor about 60 cm from the wall. Fill the pan 3/4 full of water.

❷ Put a small piece of modelling clay on the bottom edge of the mirror. Then place the mirror in the pan. Lean it against one of the short sides so that the shiny side of the mirror is facing up and towards the wall.

❸ Have a partner hold the flashlight above the pan. Shine the flashlight at an angle into the water so that it reflects off the mirror and onto the wall.

❹ Keep moving the flashlight up and down until an unusual band of light appears on the wall. Tape a piece of white paper to the wall where the light is.

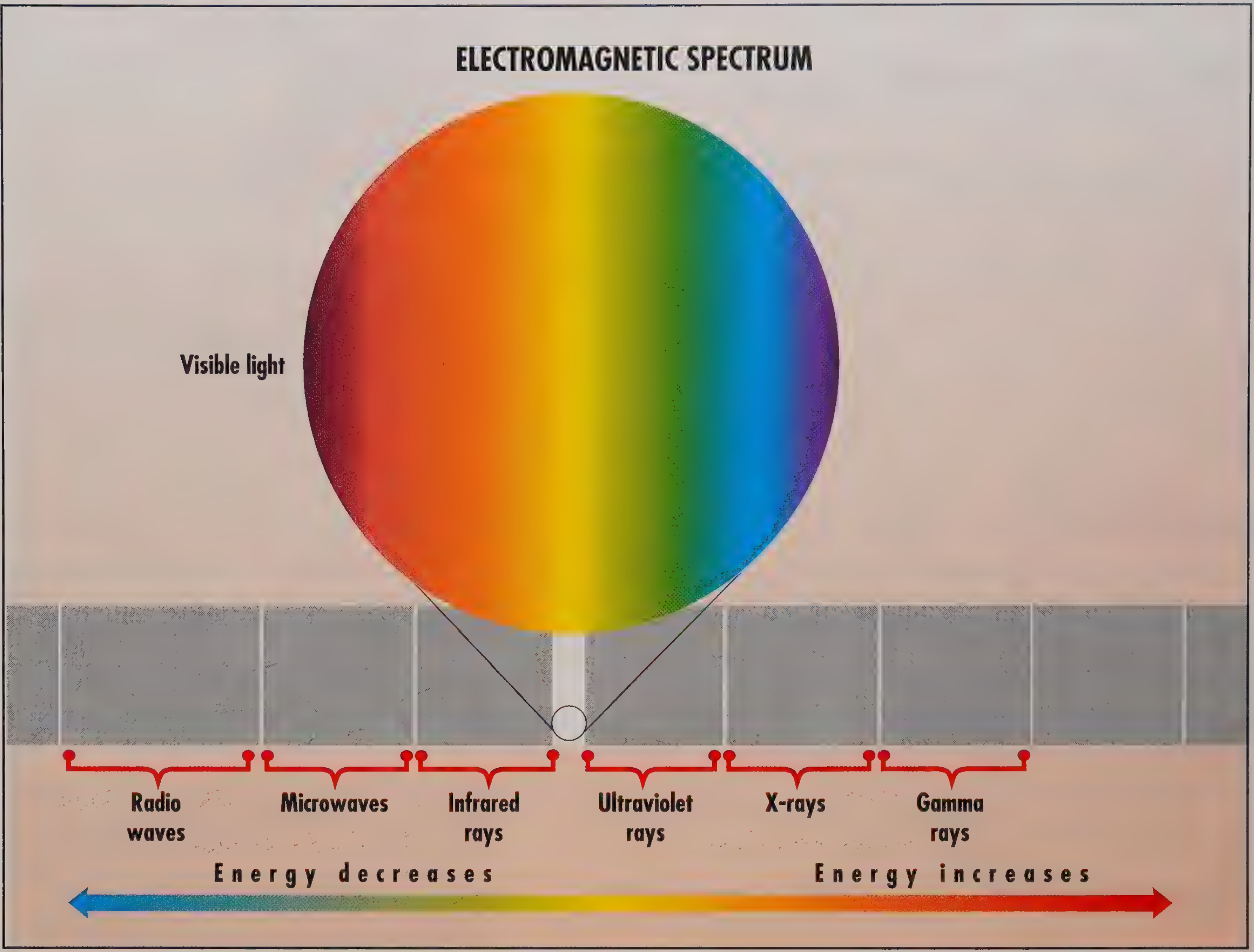
❺ Hold the flashlight so that the image shines on the paper. Then use crayons to copy the image onto the paper.

Interpret your results.

- What does your "water-and-mirror" prism show about the light that passed through it?

Communicate your results.

- Report to the class how your drawing of the prism's image is like the photograph of the glass prism above.


ELECTROMAGNETIC SPECTRUM

Exploration Connection:
The electromagnetic spectrum

The band of light you saw on your wall is a **visible spectrum**. The visible spectrum is part of a much larger band of energy called the **electromagnetic spectrum**. Which forms of energy in the diagram have you heard of before? How are they used?

Can you see radio waves or microwaves? Your sense organs do not respond to these parts of the electromagnetic spectrum. The part of the spectrum you can see is called **visible light**.

Look around the classroom at all the colours in clothes, books, plants, and posters. Every colour you see is made up of a combination of the colours in the visible-light spectrum.

Some animals can sense a different part of the electromagnetic spectrum. To find out more, check in library books, CD-ROMs, and the Internet.

Think!

What colours make up the light from your flashlight?

What Causes Colour?

You have observed this property of light: *White light can be* dispersed—*separated into colours*. The many different colours you see are part of the spectrum of visible light. But what happens when different colours strike your eyes at the same time?

Exploration:
Combine light.

You need:
- 6 cm circle template or compass and ruler
- pen or pencil
- scissors
- black posterboard
- short pencil
- modelling clay
- red, yellow, green, blue markers
- ruler

❶ Use a template or compass to draw seven circles, each 6 cm in diameter (across). Cut out the circles. Put a circle on the posterboard, trace around it, and cut out the posterboard circle.

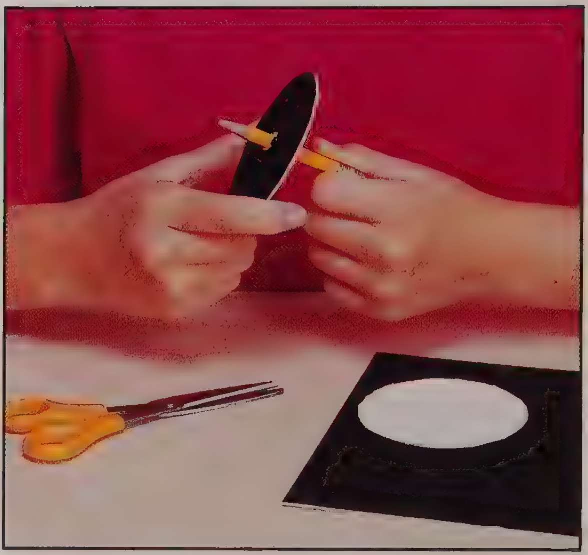
❷ Using the short pencil, poke a small hole through the centre of the posterboard circle. Push the pencil through the circle until 2 cm sticks through the other side. You have made a top.

❸ Stick a small lump of modelling clay to the bottom of the circle to give it mass and balance. Spin the top. If it does not spin evenly, move the modelling clay around until it does.

❹ Colour a paper circle half yellow and half red. Poke a hole in its centre. Push the paper circle onto the pencil so the paper is flat against the circle, coloured side up.

❺ Spin the top as fast as you can. What colour do you see when the top is spinning? Colour and spin other circles with different amounts of red and yellow. Each time you spin a different circle, record the results.

❻ Colour another circle red and green, put it on your top, and spin it. Colour and spin other circles with different amounts of red and green and blue.



Interpret your results.

- How did the circles change when you spun them? Explain why.

Communicate your results.

- Make a chart to show how colours mix to create new colours.

Closer to Home:
Colour vision

You are so used to seeing colours that you probably do not think much about *how* you see them. Seeing colour really has three parts.

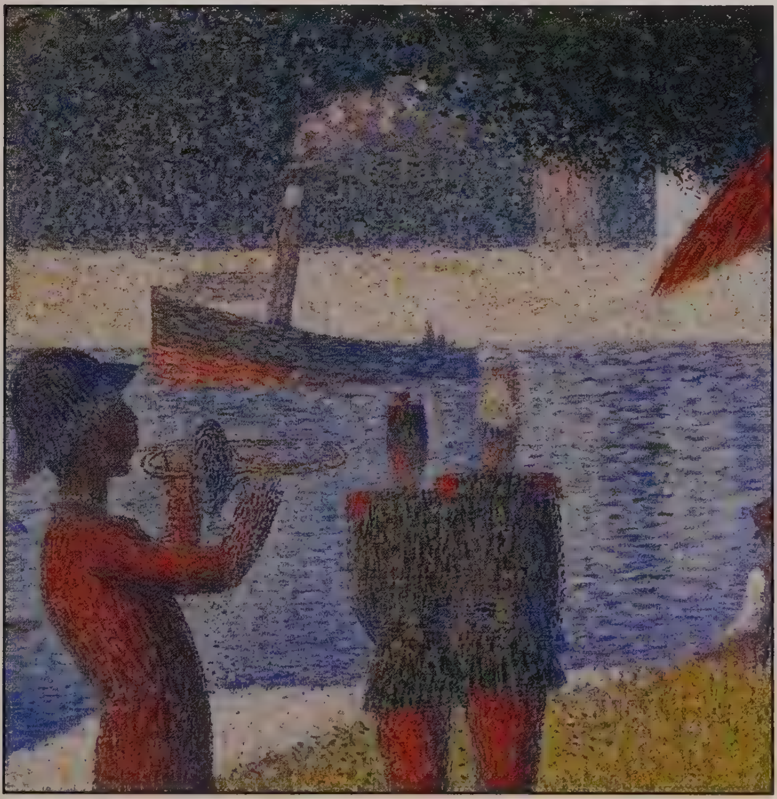
First, when light is dispersed—refracted into the spectrum—each part has a different wavelength—and each wavelength is a different colour. When white light reaches an object, all the colours of light reach the object.

Second, most objects have substances called pigments. Pigments absorb some of the light that hits them, and reflect the rest. Different pigments absorb different colours of light. The light they do not absorb is the colour you see.

Third, nerve cells in your eyes react to light and send signals to your brain. If you wake up in the dark, you can see objects around you. You can make out their shapes, but you cannot tell their colours—you need more light to see colour than you do to see shapes.

Your eyes have two kinds of nerve cells that let you see: cone cells and rod cells. The cone cells let you see the shape of an object and its colour, but they need a certain amount of light to work. Each **cone** can receive a single colour. Red cone cells react to red objects. Cone cells work together. If you are looking at an object that is reddish-blue, your red cones and blue cones both react to it.

Your eyes also have rod cells. Rod cells cannot see colour, but they do not need as much light as cone cells do. When it is dark and you see only outlines and shades of grey, you are using rod cells. Most of the rod cells are at the sides of the retina. So if you want to see an object in the dark more clearly, do not look directly at it. If you look to one side of the object, the small amount of light reflecting from it will reach the part of your eyes with the most rod cells.



Georges Seurat, 1859–1891, *A Sunday on La Grande Jatte–1884*, oil on canvas, 1884–86. 207.6 cm x 308 cm. The Art Institute of Chicago, Helen Birch Bartlett Memorial Collection. © 1993. All rights reserved.

◀ Your eye sees many small dots of colour in this detail from the painting by French artist Georges Seurat. What will the light reflected by the dots look like if you back away? Try it!

You now know how light reflecting off an object causes colour. But that is not the only way colours are made. Have you ever seen light coming through a stained-glass window? How is the way the window causes colours different from the way classroom walls cause colour?

Exploration:
Transmit light.

You need:
- flashlight
- variety of materials in different colours
- scissors

What kinds of materials change the colour of light passing through them? In a small group, talk about materials that **transmit** light—allow it to pass through. What must these materials be made of and look like to transmit light? What effect will the colour of the material have on the light passing through? Where have you seen this effect before?

❶ Find safe materials in a variety of different colours that transmit light. Carefully cut each into a practical size and shape. Work in your group to design an investigation using these materials and a flashlight. Your problem is to find out the effects of each coloured material on white light.

❷ Make a hypothesis. What shows up on white paper when you shine a regular flashlight on it? What colours of white light will each material transmit? What colours will a red square absorb? a blue square? and so on . . . Discuss your hypothesis, and then record it.

❸ What will testing your hypothesis tell you about how colours of light are transmitted?

Interpret your results.

- What colours were in the white light that you shone on the materials?
- What colours of white light did each square transmit?
- What colours did the red square absorb? the blue square?
- Was your hypothesis correct? Why or why not?

Communicate your results.

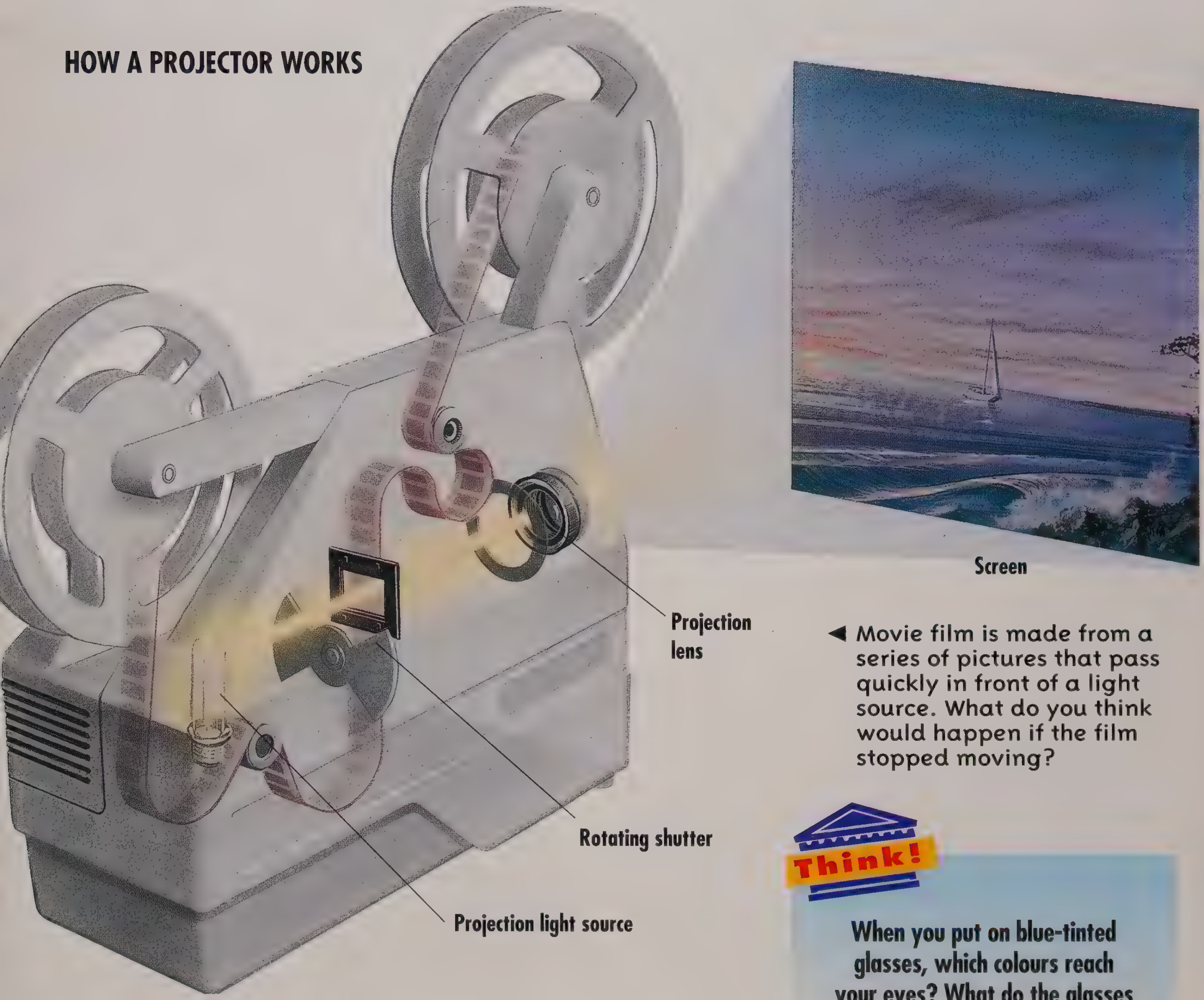
- Compare the methods and results of your exploration with those of other groups.
- Recreate your investigation for the class. Be ready to answer any questions about your results and conclusions.

Exploration Connection:
Interpreting diagrams

What goes on behind the scenes when you go to the movies? The person who runs the machines that show the movie loads the movie film into the projector. The projector beams white light onto the film. Huge coloured pictures show up on the theatre's screen. How does the movie film change the projector's white light into those pictures?

Look at the diagram and the picture of the movie film. Like the red and blue squares you used, film is made from a material that lets some light pass through. The yellow parts of the frame transmit yellow—they allow yellow light to pass through. The blue parts transmit blue light, and so on. What colour of light is transmitted by the black parts?

HOW A PROJECTOR WORKS



◀ Movie film is made from a series of pictures that pass quickly in front of a light source. What do you think would happen if the film stopped moving?

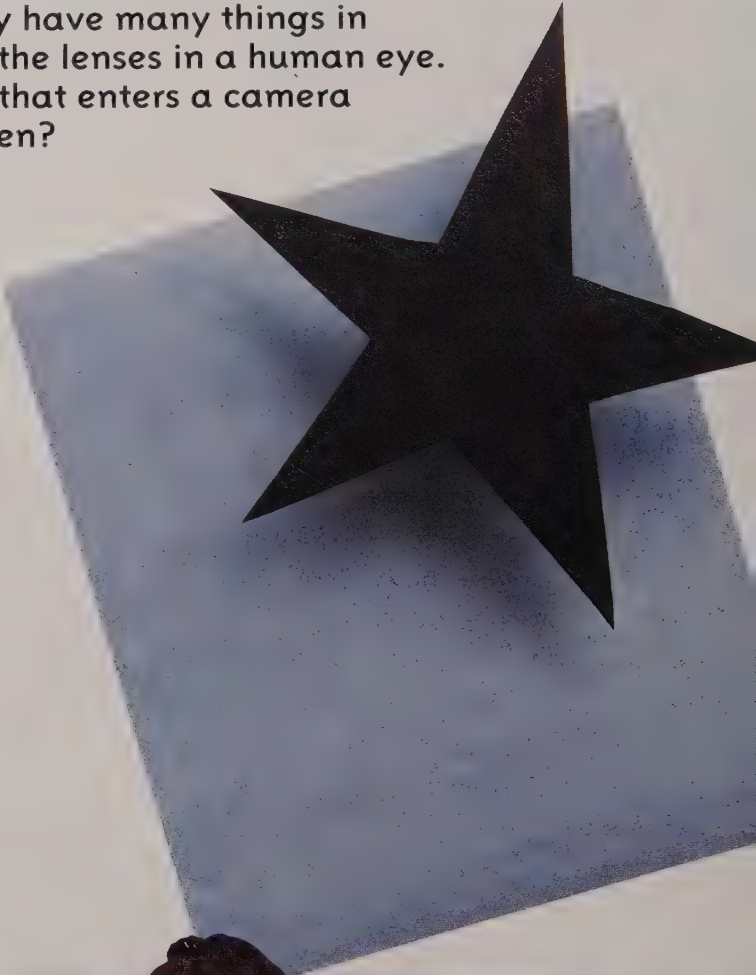
Think!

When you put on blue-tinted glasses, which colours reach your eyes? What do the glasses do to the other colours of light?

LESSON 10

What Happens to Matter That Absorbs Light?

Movie film can be used to project big colourful pictures. Similar film is used to make slides. Although a movie camera and a camera that uses slide film are different in some ways, they have many things in common. Both cameras have lenses similar to the lenses in a human eye. What part of the eye is the film like? The light that enters a camera strikes the film. What do you think happens then?



Exploration:
Make sunprints.

You need:
- scissors
- black construction paper
- sunprint paper
- aluminum pan
- tape
- tracing paper
- pencil
- water

❶ Cut a shape from black paper.

❷ Place a piece of sunprint paper, blue side up, on a flat surface. Place the black paper shape you made on the sunprint paper.

❸ Put the papers in sunlight for 2 to 5 min.

❹ Remove the sunprint. Put it in a pan of water for 1 min. Lay it out flat to dry.

❺ Cut a shape from the tracing paper. Make a sketch on the paper with a pencil. Repeat steps 2–4 using a fresh sheet of sunprint paper and a tracing-paper shape.

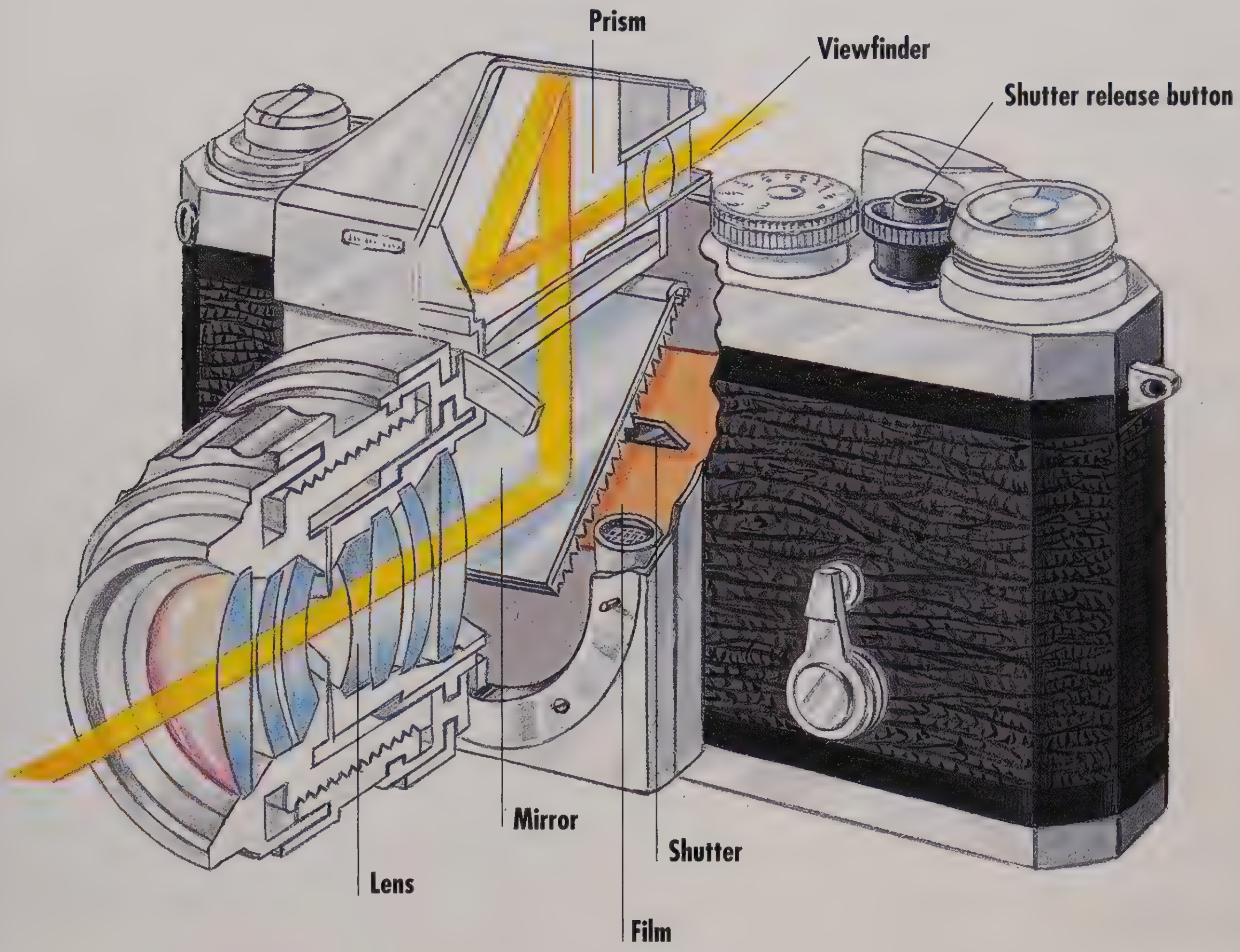
Interpret your results.

- Objects that do not allow light to shine through, like black paper, are **opaque**. Objects that let some light through, like tracing paper, are **translucent**. How are sunprints made by opaque and translucent objects different?

Communicate your results.

- Sunprint paper is coated with chemicals. What must be true about those chemicals?
- Report your conclusions to the class.

HOW A CAMERA WORKS



Information Connection:
Interpreting diagrams

This diagram shows how a camera that uses slide film works. With your finger, trace the path of light passing into the camera and out of the viewfinder. Compare the angles at which light hits the mirror and then reflects onto the prism.

If you press the shutter release, the mirror rises and exposes the film to light. Images form on the film when it is exposed to light, just as they did on sunprint paper. After the roll of film has been exposed, it is soaked in different chemicals to develop the images.

- Do you ever use a film or video camera? Share your camera experiences with the class.
- How many inventions can you list that use light in order to work? Check the Internet, CD-ROMs, library books, and other print and non-print resources.

▶ After the slide film has been turned into a "positive," it is cut into small pieces and mounted in frames. Why?

Light is amazing. White light contains all the colours of the spectrum. After zipping through a camera, light forms a permanent image on a piece of paper. Film is not the only thing that reacts with light. **Phosphorescent** matter also absorbs light and does something unusual with it. Do you know what it does?

Exploration:
Investigate phosphorescent plastic.

You need:
- phosphorescent plastic toy
- cardboard viewing box
- high-intensity lamp (optional)

❶ Put the phosphorescent plastic toy in a sunny place or under a high-intensity lamp for an hour. Then place it in the cardboard box.

❷ Darken the room and look at the toy in the dark. What do you see? Where did the toy get its energy? Touch the toy. Is the plastic hot?

❸ Open the curtains, or turn on the lights. What do you see?

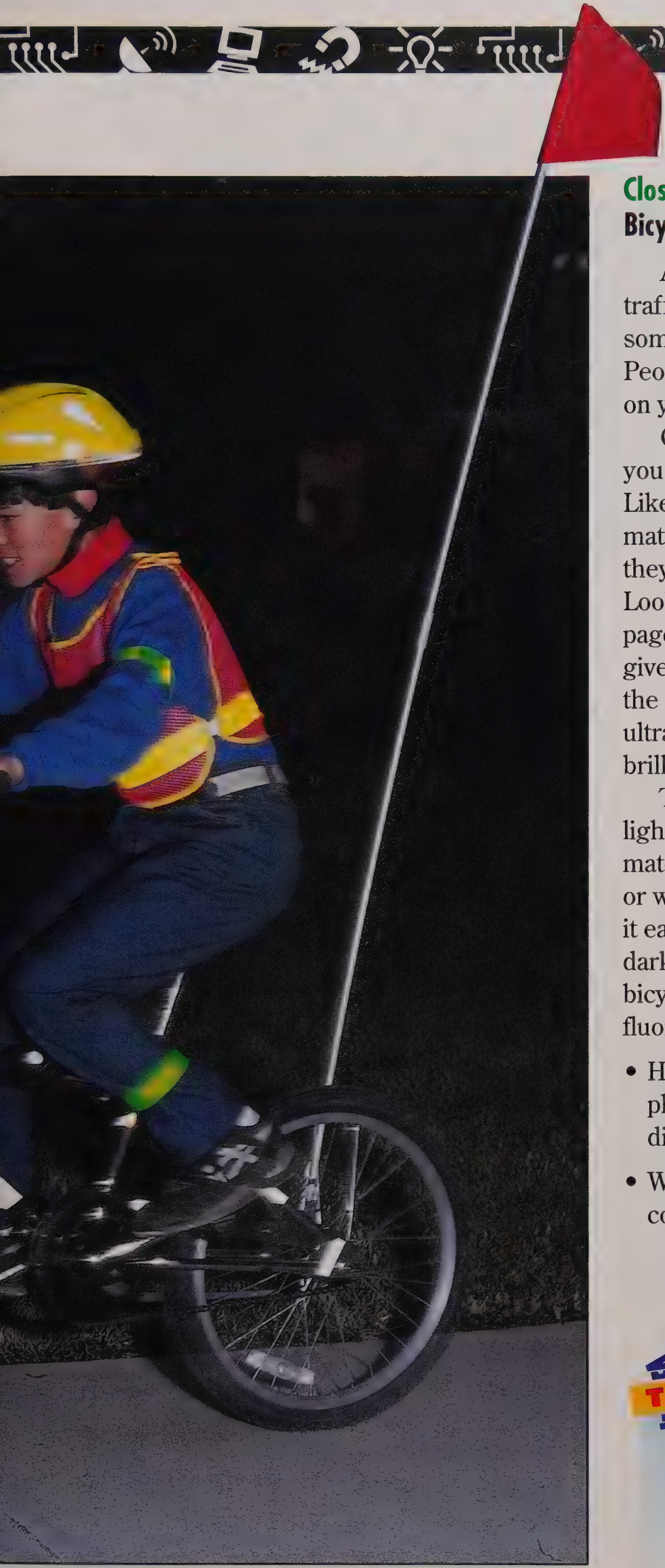
Interpret your results.

- Could you see the plastic object when the classroom was darkened? Why or why not?
- Where did the plastic toy get the energy to produce light?

Communicate your results.

- How could phosphorescent plastic be useful at home? at school? in a movie theatre? Discuss your ideas in a group, and then record your conclusions in your science journal.

▲ What makes this cyclist safer than many other cyclists?



Closer to Home:
Bicycle safety

Are you a bicycle rider? Do you ride in city traffic or on country roads? Riding a bicycle can sometimes be nerve-wracking—even dangerous. People in cars do not always see the reflectors on your bicycle wheels and pedals.

Certain materials can help protect you when you are riding a bicycle or walking in the dark. Like phosphorescent materials, **fluorescent** materials absorb light energy and release it, but they release it much faster—almost immediately. Look back at the electromagnetic spectrum on page 29. A fluorescent object absorbs light and gives off light with lower energy. For instance, the pigments in fluorescent paint absorb ultraviolet light and then give off shimmering brilliant colours.

This special property of releasing absorbed light almost immediately makes fluorescent materials very useful for people who ride bikes or walk in the dark. Fluorescent materials make it easier for the driver of a car to see you in the dark. Fluorescent stickers can be put on a bicycle helmet. You can wear bands made of fluorescent cloth on your arms and ankles.

- How are fluorescent objects and phosphorescent objects alike? How are they different? Discuss in a group.
- What are other ways fluorescent materials could help be helpful?

Think!

What are the eight properties of light? If you need help, quickly look back at the first 9 lessons.

How Does Matter Change Light?

You have seen how phosphorescent plastic keeps glowing after it has been exposed to light. What do you think happens to the light itself when matter absorbs it? Think about sunlight that comes through a window onto your face. How does your face feel? What do you think has happened to the sunlight that came through the window?

Exploration:

Change light energy.

You need:
- cardboard box
- black paper
- tape
- 2 clear plastic cups
- water
- clear plastic wrap
- 2 tea bags
- clock or watch

❶ Line the inside of the box with black paper. Use tape to hold the sheets of paper in place. Set the box in sunlight, with the open side facing the light source.

❷ Fill both cups with cold water. Put one cup in the box, making sure that no part of the cup is in a shadow. Put one tea bag in the cup. Tape clear plastic wrap over the open end of the box.

❸ Put the other tea bag in the second cup. Place the cup in a place where it gets no direct sunlight.

❹ Observe your two cups once every 5 min for the next hour. Record any changes.

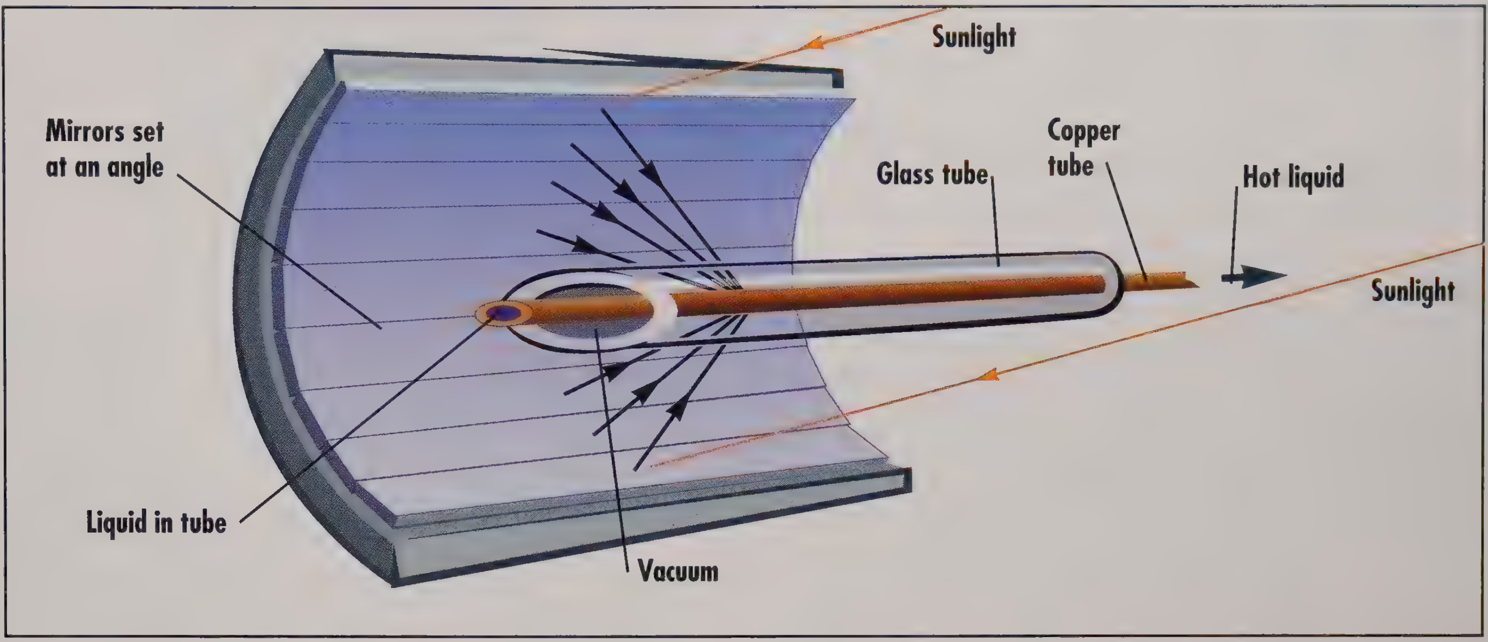
Interpret your results.

- You just made a **solar water heater**. *Solar* means "sun-powered." Why is this a good name for the device?
- In which cup did the water heat up? Why?
- You know that a light bulb changes electric energy to light energy. What does a black surface change light energy to?

Communicate your results.

- Which would warm up faster during the day, a swimming pool painted black or a pool painted white, green, or blue? Explain your answer to a classmate.

VACUUM TUBE COLLECTOR



Information Connection:
Solar power

In some places, the water in homes, schools, and offices is heated by solar energy systems similar to the one you made. The picture on the right shows one of these systems.

The heat a solar heater can add to water depends on two things: the size of the heater and the amount of sunlight that reaches it. Different places receive different amounts of sunlight, and the same place receives different amounts throughout the year. The heat from the sun is stronger in some places because they are closer to the sun.

You made a simple solar heater. The diagram above shows an improved vacuum tube collector. The tube has no air inside it, so none of the heat it collects can escape. This makes very hot water—much hotter than you need in your bath!

- Study the diagram of a vacuum tube collector. Explain how it works to a partner.
- What do you think the advantages are of such a vacuum tube collector? its disadvantages?
- Would your community be a good place for solar hot-water heating? Why or why not?
- What time of the year would be best for collecting solar energy? Explain in a poster using charts and diagrams.

▲ The solar panels on this house use light energy from the sun to heat water for an entire family.

Closer to Home:

Sun problems and sun solutions

Energy from the sun makes life on Earth possible. But some kinds of sun energy can hurt life. At each end of the electromagnetic spectrum are two invisible but very important kinds of energy. Just beyond the red what we can see is infrared radiation (IR). And just beyond the violet what we can see is ultraviolet radiation (UV). The IR is the part of the spectrum that gives us the heat from the sun. The UV is the part that gives us a suntan. A suntan may look nice, but too much sun can cause unpleasant sunburn or even lead to skin cancers. The sun's UV rays come in three groups of different wavelengths.

UV-A is the weakest of the UV rays. It tans us right away and is often used in tanning parlours. It can also lead to skin aging and wrinkles. UV-A can also damage outdoor plastic and paint.

UV-B is the most harmful to humans and other life forms. It leads to delayed tanning, burning, and aging of the skin. UV-B can cause skin cancer and a clouding of the eye that makes seeing difficult. UV-B also slows the growth of plants, and may affect the health of animals.

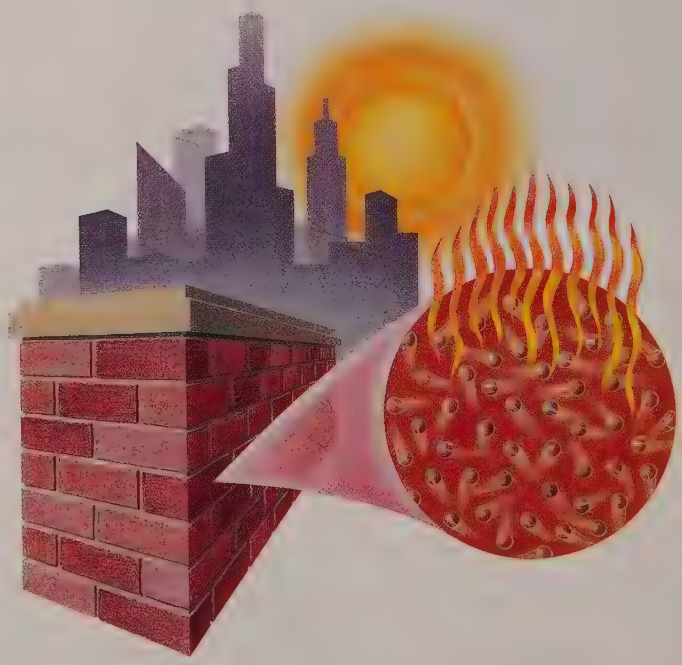
UV-C is the shortest wavelength and the most harmful. But UV-C never reaches the Earth's surface.

Newspapers and TV stations report a daily UV index to tell us when to stay out of the sun. In Canada, UV is measured on a scale of 0 to 10. The higher the number, the more UV you will get, and the faster you will sunburn. The farther south you go, the higher the UV. That is why you burn quickly on a southern vacation.

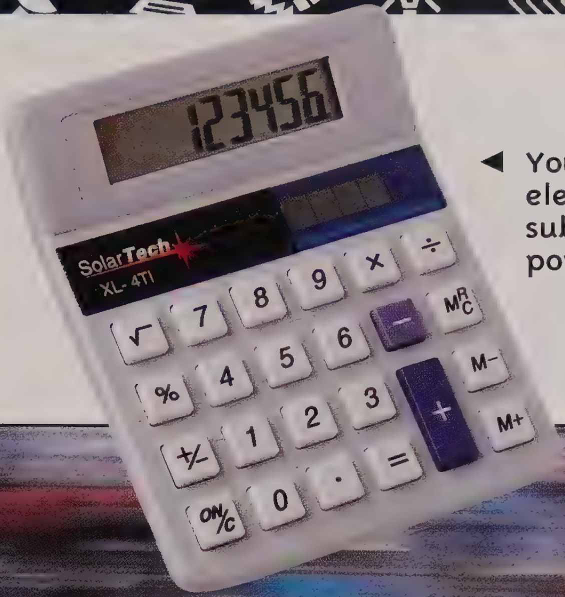
- Look at the UV index above. When it is over 9, UV-B is very strong, and you will burn in less than 15 min. (Sunburn times are for light, untanned skin. The times would be slightly longer for those with darker skin.)

UV Index	Category	Sunburn time
over 9	extreme	less than 15 min
7-9	high	high about 20 min
4-7	moderate	about 30 min
0-4	low	more than 1 h

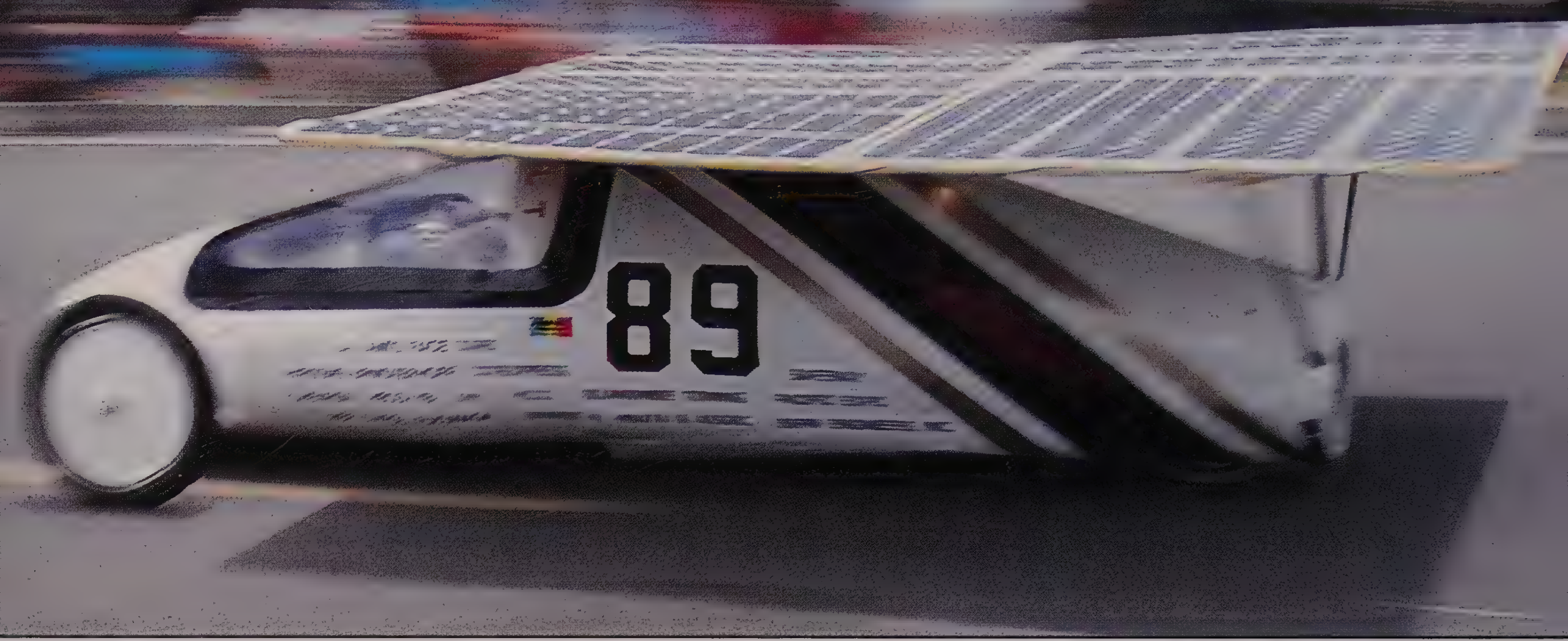
- What is the UV index in your community today? How long would you have to be in the sun to get a sunburn? Remember that the sun is strongest from 11 A.M. to 4 P.M.
- Your sunscreen should block both UV-B and UV-A, and have an SPF—sun protection factor—of 15 or more. How can you protect yourself from harmful UV rays?



▲ The sun's energy can excite the particles in the bricks of a building. The particles move faster and produce heat. Put your hand on a dark- and a light-coloured brick on a sunny day. Which is hotter? Why?



◄ You do not need an electrical outlet to add or subtract with this solar-powered calculator.



▲ High school students built this solar-powered car. They took it to Hawaii and competed with other students. How would this car perform where you live?

Like the solar heater in this lesson, the devices shown on this page change light to other forms of energy. They do not need batteries, gasoline, a wall outlet, or any other source of energy—just light.

- What forms of energy do you think a solar-powered calculator changes light to?
- How many different forms of energy does a solar car change light to? What are they?
- Imagine that you work as a city planner in a city that gets sunlight on more than 90 percent of the days of the year. What suggestions would you make that might help your neighbours stay comfortable?

Think!

Alligators are cold-blooded reptiles. Why do they spend most of the winter lying motionless in the sun?

A Identify Problems: Lighting a Space Station

A storm knocks out power to your neighbourhood. All you have to do is call the hydro utility, and a repair crew is on the scene. But how different would this situation be for the crew of a space station? In space, there are no downed wires or overhead power lines to repair.

A First, you will identify the problems you would face in designing a lighting system for a space station.

B Next, you will identify some possible solutions to those problems.

C Then, you will make a model of your lighting system, showing the parts of the system and how they work.

Problem: Your group of engineers has been hired to invent a lighting system for a space station. Ten people will live on the space station for one year. The station has a control centre, a laboratory, a crew's quarters, a bathroom, a greenhouse, a small exercise room, and a kitchen/dining space. Your group must put together a plan describing how the station will be powered and how each room will be lit.

These questions will help you identify the problems you will face while trying to design a lighting system:

① What energy sources will power the lighting system?

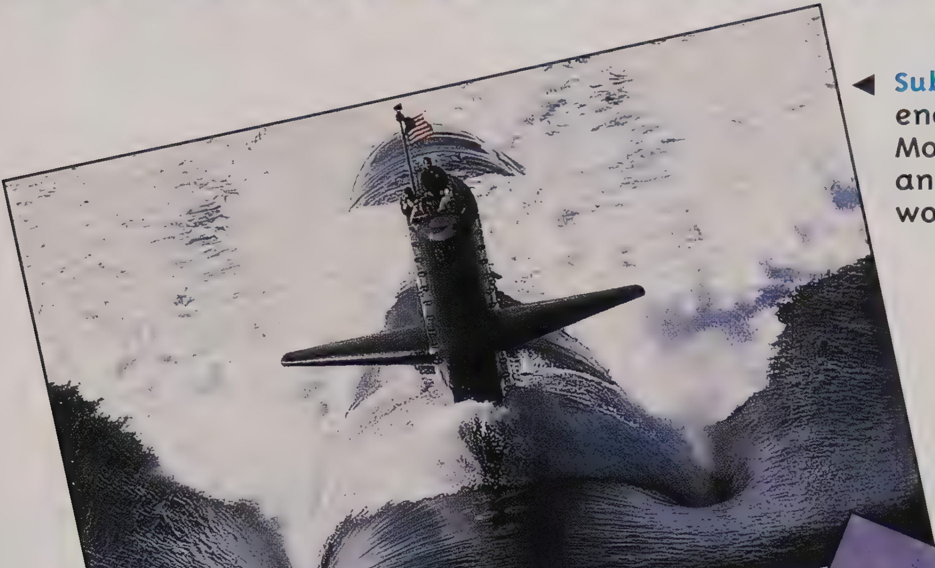
② How will the parts and equipment for the lighting system be transported into space?

③ What parts are likely to break down or wear out? Where will replacement parts come from?

④ What kinds of activities will the 10 people in the space station need light for?

⑤ What kinds of lighting will be used? Will the same kinds be suitable throughout the station?

⑥ Engineers designed lighting systems for each workspace shown in the pictures. What problems did the engineers who worked on these projects have to solve in designing the lighting system of each project?



◀ **Submarine** A submarine carries an energy supply for its lighting system. Most submarines are nuclear powered and do not need any air to work. Why would that be important?

▶ **Antarctica research station** An Argentine research base sits in the remote wilds of Antarctica. It is totally isolated, so how does it get the energy it needs? The small yellow building to the right houses an electric generator that produces energy for the station.

▲ **Underwater research lab** Underwater habitats are used by some scientists who study the ocean. Most underwater habitats are not far from land. Cables carry electricity from an energy supply on land to the underwater habitat shown here. Many habitats also have batteries that store enough electricity to run the habitat's light and air systems in an emergency.

Think!

Of the workspaces shown, which one's lighting system is probably the best model for a space station lighting system? Why?

B Find Solutions: Lighting a Space Station

Solving special lighting problems:

Engineers design all kinds of structures, machines, and devices for industry and everyday life. They plan how things like dams and power stations will be constructed and show how the various parts will work.

Until several hundred years ago, most engineers were military or civil. Military engineers designed devices to be used in battle. Civil engineers designed harbours and built bridges and buildings.

Now there are electrical engineers—who may design lighting systems, aerospace engineers—who design spacecraft, mechanical engineers, chemical engineers, and many others.

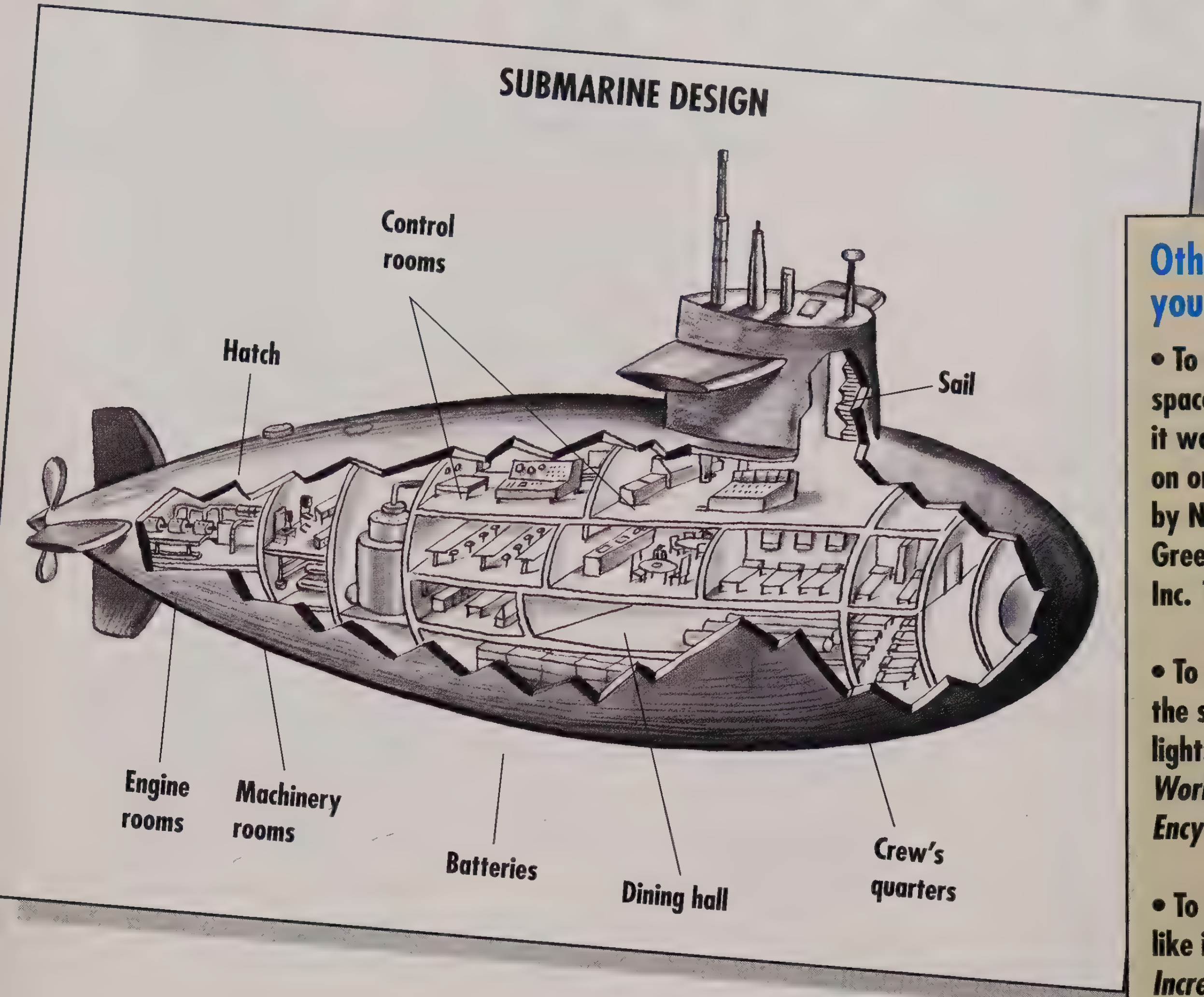
You have just made note of some problems engineers faced in designing lighting systems for unusual workspaces. Now take a closer look at one of them—a submarine. Thinking about how engineers lit an underwater vessel might help you and your group find solutions to lighting a space station.

1. Make a chart of the problems you listed in the last section. Beside each of your problems, try to list a similar problem the lighting engineers for the submarine had to face.

2. Study the diagram of the submarine. Where is its power source? What are the spaces that need lighting? A submarine spends months below the surface of the water. How does this affect the type of lighting a submarine needs? What are some special problems that might occur? Below each submarine lighting problem on your chart, record solutions you find. Could you use any of their solutions for *your* problems?

3. Think about the batteries you used as you worked on this unit. Are they as powerful now as they were at the beginning of the unit? Could the same type of battery be used on a submarine? How about on a space station?

4. Below each of the space station lighting problems on your chart, record any solutions you can think of. If you have more than one solution to a problem, record them all. You can use both words and pictures.



Other resources you can check . . .

- To find out more about space stations and what it would be like to live on one: *Living in Space* by Neal Bernards. Greenhaven Press, Inc. 1990.
- To find out more about the sources of electric light: "Electric Light," *World Book Encyclopedia*, Volume 6.
- To find out what it is like inside a submarine: *Incredible Cross-Sections* by Stephen Biesty. Alfred A. Knopf, 1992.
- You can also search the Internet for information on these topics.

▲ **Passenger sub in the Grand Cayman Islands** Strategic lighting allows the engineer to operate the submerging controls of this submarine.

Think!

How does learning about the ways engineers have solved other lighting problems help you with your problems?

C Design and Construct: Lighting a Space Station

Possible models for your lighting system:

Diagram Use the diagrams on pages 44–47 to help you draw a large diagram of your lighting system. Be sure to label the diagram to show your solutions.

Build It! Use cardboard, plastic, or any combination of items to build a model showing a space station and its lighting system.

Written Description Write a report that carefully describes every detail of the lighting system you have designed for the space station.

Computer Graphics Use a graphics program on the computer to design a lighting system.

Oral Presentation Give a talk about your lighting system as though your group were making a presentation to other aerospace engineers.

Your group has identified problems you will face in designing a lighting system. You have also identified possible solutions to some of those problems. Now it is time to put your solutions to work.

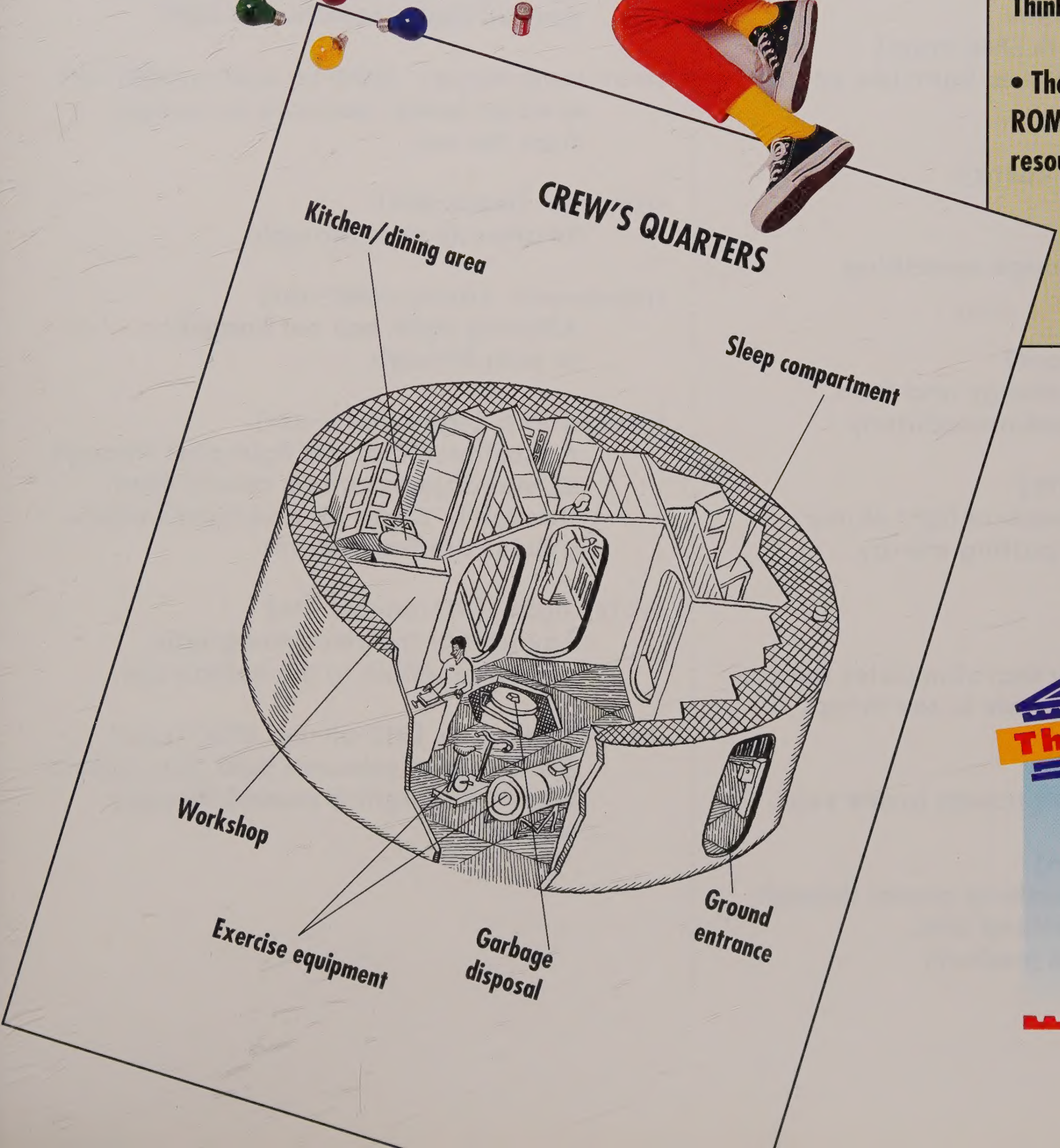
1. Study the diagram. How does the structure of each area in the space station affect the type of lighting you will use? What part of the space station will supply electricity for your lighting system? What source of energy is most easily available to a space station?

2. Work with your group to design a lighting system. List all the things your lighting system should have. Make sure your design includes these things.

3. Make a model based on your design. Choose one of the models you think will work best for showing your lighting system. Gather the materials you need and start working.

4. Look at all the models your class has made. How did different groups solve problems? Did all the groups think of the same problems? the same solutions?

5. How would your models have been different if you had *not* learned how light sources work, how light travels from its source, and what happens to matter that absorbs light? What were the most important things you learned in this unit that helped you design a lighting system?



Resources for putting together a lighting system:

- Your own science journals for the investigations in this unit are filled with valuable conclusions you have made about light.

- Look back at Lessons 1–11 of this Student Book. Look especially at the text near the Think Tank symbols. These symbols tell you when something you have learned may help in solving your Think Tank problems.

- The library books, CD-ROMs, Internet, and other resources you have used all through this unit are filled with information about light.

Think!

How did making a model help you think of problems and solutions you missed before?

Glossary

concave: [kon-KAVE]
Hollow and curving inward.

cones: [kones]
The three types of colour receptors in the eye.

convex: [kon-VEKS]
Curving outward.

dispersion: [dis-PUR-shun]
The splitting of light into its different wavelengths or colours, as when light goes through a prism.

electric circuit: [ih-LEK-trik SUR-kit]
The path of travel for an electric current.

electric energy: [ih-LEK-trik EN-ur-jee]
The energy created by a flow of electrons.

electromagnetic spectrum:
[ih-lek-troh-mag-NET-ik SPEK-trum]
All bands of light and light-like energy.

emit: [ee-MIT]
Give or send out energy.

energy: [EN-ur-jee]
The ability to change something or do work.

fluorescent: [floor-ES-unt]
Absorbing light energy and then releasing it almost immediately.

laser light: [LAY-zur LITE]
A very intense beam of light of one colour made by putting energy into a material.

light: [lite]
A form of energy that stimulates the eye and makes it possible to see things.

light-year: [LITE-yeer]
The distance light travels in one year.

medium: [MEE-dee-um]
A substance something passes through or in which something acts. Copper is a good medium.

opaque: [oh-PAKE]
Not allowing light to pass through.

phosphorescent: [fos-fuh-RES-unt]
Glowing after the light source has been removed.

prism: [PRIZ-um]
A block of glass or plastic that separates white light into the colours of the visible spectrum.

reflect: [rih-FLEKT]
To throw or bounce back.

refract: [rih-FRAKT]
To cause a change in the direction of a light beam.

retina: [RET-un-uh]
The layer of cells at the back of the eyeball that is sensitive to light.

solar water heater: [SOH-lur WOT-ur HEET-ur]
A water heater powered by energy from the sun.

transmit: [tranz-MIT]
To allow to pass through.

translucent: [tranz-LOOS-unt]
Allowing light, but not images, to pass through.

transparent: [tranz-PARE-unt]
A substance that lets light pass through so that objects can be clearly seen through it. Clean air and most window glasses are transparent.

visible light: [VIZ-uh-bul lite]
Any part of the electromagnetic spectrum visible to the human eye.

visible spectrum: [VIZ-uh-bul SPEK-trum]
The bands of coloured light that appear when white light is passed through a prism.

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